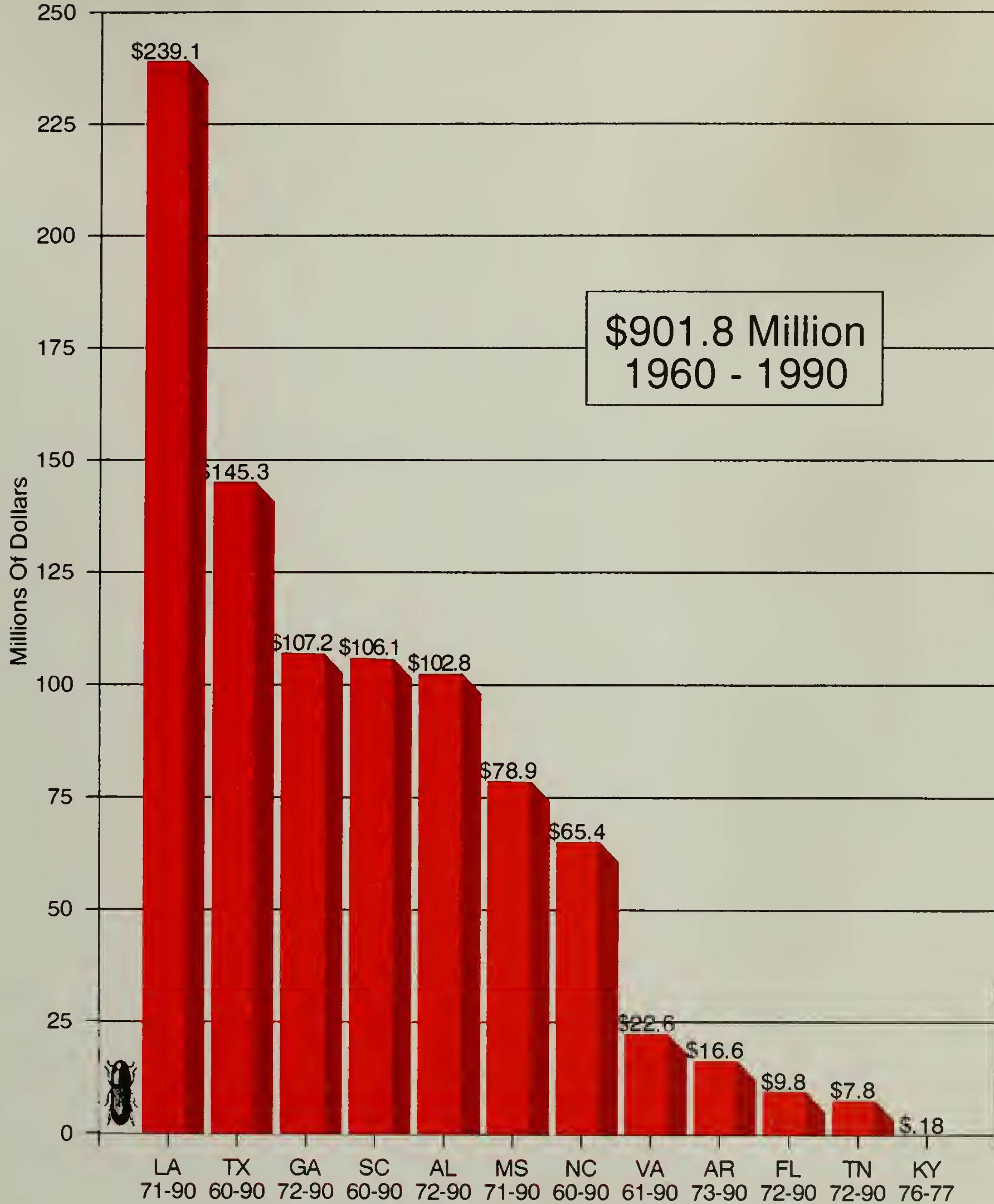
A History of Southern Pine Beetle Outbreaks In the Southeastern United States

By the Southern Forest Insect Working Group



TPBRPB02 IMA

ACKNOWLEDGMENT

The authors would like to thank Dr. Ronald Billings and Mr. Joe Pase, Texas Forest Service, for editing and adding to the Section on History of Southern Pine Beetle Control. Also, thanks are extended to Wes Nettleton, USFS, FPM for a critical review and to Mrs. Glynda Thornton, Administrative Secretary, Georgia Forestry Commission, for typing the report.

Funding for this report was provided by the USDA Forest Service, Forest Pest Management Southern Region, Atlanta, GA and the Georgia Forestry Commission, Macon, GA. The USFS, SEFES, Research Triangle Park, NC produced the distribution maps (Figures 1-31).

A HISTORY OF SOUTHERN PINE BEETLE OUTBREAKS IN THE SOUTHEASTERN UNITED STATES

Edited and Compiled By
Terry S. Price[1/], Coleman Doggett[2/], John M. Pye[3/], and Tom P. Holmes[3/]
For The
Southern Forest Insect Working Group[4/]

The southern pine beetle, Dendroctonus frontalis Zimm., is the most destructive insect killer of pines in the southeastern United States. This native bark beetle attacks and kills southern pines in an area roughly approximating the geographical range of shortleaf pine (See Appendix). For poorly understood reasons, the insect periodically increases to epidemic proportions, causing severe timber losses. For many years, a vast amount of data on the beetle have accumulated in files and archives. Some of the early information is very sketchy, but data collected since 1960 are reasonably accurate. This publication summarizes historical information on the southern pine beetle and documents damage and spread of the beetle since the 1960's.

METHODS

The data shown in Table 1 and Figures 1 to 31 were collected to provide a regional record of long term patterns of southern pine beetle outbreak. Such broad scale datasets are crucial to proper understanding of factors which control episodically varying pests,

---

1/ Forest Entomologist, Georgia Forestry Commission, Macon, GA.
2/ Pest Control Forester, N. C. Division of Forest Resources, Raleigh, NC.
3/ Ecologist and Research Forester, respectively, USFS, Southeastern Forest Experiment Station, Research Triangle Park, NC.
4/ The SFIWG consists of state and federal forest pest control specialists. Individual contributors are listed in the Appendix.

yet are rare for forest insects. However, it is important to recognize the limitations of the data presented here. These data were collected by state and federal pest control specialists to assist their own pest control objectives as well as to fulfill federal cost-sharing reporting requirements. Fundamental differences in methodology are inevitable particularly in light of the regional coverage and lengthy period described. Such differences necessarily limit the comparability of the data.

The two types of data presented in this publication, county-level outbreak intensities (Figures 1-31) and state-level damage estimates (Table 1), are derived from three sources of information: aerial spot detection surveys, ground checks of detected spots, and surveys of host forest extent. This section defines the data presented and describes how it was assembled.

Aerial surveys: Because host damage and reproduction by southern pine beetles occur primarily in well defined patches called spots, locating and enumerating spots is fundamental to estimating their population and impact. Active spots are principally identified through detection flights (Hain, 1980). Flights are conducted periodically throughout the active season, with flight timing dependent on expected level of beetle activity, season, objectives, and operational capabilities (Billings, 1979). States do not record very small spots, less than five or ten trees in size, because of their limited potential for damage[5], and for programmatic reasons some states do not survey or report spots on federal lands. Survey efforts may historically have been less intensive during years of

5/ For example, Texas increased its detection threshold to ten active trees in 1974 (Billings, 1979).

limited beetle activity or in counties thought to be at low risk, leading to under reporting of spot numbers. Dull (1980) discusses some of the sources of error associated with aerial spot detection.

Ground checks: Pockets of mortality observed in the air may be caused by other agents than southern pine beetle. Ground checks allow confirmation of the beetle's role and permit improved estimation of spot size for subsequent damage estimates (Mayyasi et al., 1975). States may prioritize detected spots by their damage potential, restricting ground checks to those spots most likely to benefit from control (Billings, 1979)[6].

Host surveys: Because southern pine beetle only attacks certain species of pine, measures of spot frequency are typically expressed relative to the amount of potential host available. For the maps in this publication, spot numbers in each county have been divided by that county's acres of susceptible forest, producing "spots per thousand acres of susceptible host type."

"Susceptible host type" refers to forests dominated by suitable host species. Loblolly and shortleaf pines are the most common host species of southern pine beetle, although pitch and Virginia pines are also susceptible. White, slash and longleaf pines are rarely attacked by southern pine beetle and thus are not treated as susceptible. Pines within mixed forests can be attacked, although less frequently than in stands with high pine basal areas (Lorio, 1980).

6/ Because beetle activity was light in 1989 and 1990, SC performed no ground checks.

All the states in the survey obtain their county-level estimates of acreage by forest type from the U. S. Forest Service's Forest Inventory and Analysis (FIA) survey. States combine the acres in the FIA forest type categories "loblolly-shortleaf" and "oak-pine" as their estimate of susceptible acres[7]. The FIA survey is conducted approximately every ten years, with states apparently using the most recent survey data available for their calculations[8] Thus estimates of susceptible acres can be up to ten years out of date.

Levels of infestation: The above descriptions suggest that the states forwarded to us estimates of spots per thousand acres. This is generally not the case. Rather, most state infestation levels have been reported by broad categories. For the years prior to 1978, data are only available on whether a county was in outbreak status or not, where one spot per thousand acres or greater serves as the definition of outbreak. Starting in 1978, infestation levels have been divided into three ranges:

Category	Spots per thousand acres susceptible host type
Low	0.1 to just under 1
Middle	1 to just under 3
High	3 and greater

The new "low" category captures less intense infestations than were reported in earlier periods -- only the middle and high categories fit the previous definition of "outbreaks."

Damage estimates: State-level damage estimates (Table 1) are divided into pulpwood and sawlog volumes killed and estimated amounts

7/ For GA, prior to 1972, only one-half of all mixed oak-pine acres were included as susceptible.

8/ For 1972-1990, GA estimates were based on linear interpolations between survey years.

salvaged, with volumes valued using that year's statewide prices. Estimates of amounts killed and salvaged are derived from spot counts, ground checks, and other available information. Estimates of that year's statewide stumpage values are then simply applied to the volumes killed to produce estimates of total value of loss.

Update: This publication updates data found in an earlier publication (Price and Doggett, 1982) which presented similarly collected data on outbreaks from 1960 through 1980. These older data are reproduced here for the convenience of the reader. Only data for Georgia from 1972 to 1980 were revised, based on improved estimates of susceptible host acres[9]. Data for all states after 1980 were solicited for this publication from the state and federal pest control specialists listed in the Contributors section and maps were proofed by the responsible contributor for accuracy. Their assistance has been essential to this effort and is gratefully acknowledged.

DISCUSSION

Even prior to the time the southern pine beetle was first described by Zimmermann in 1868, pine mortality was described by early writers which may be attributed to the beetle. The first outbreak on record was reported by several writers in the late 1700's and early 1800's. Since it was reported in east Tennessee, coastal plain North Carolina, South Carolina, and Georgia and piedmont North Carolina, it was probably southwide.

9/ The previous version had used more dated estimates of host acres and had included one-half of the mixed oak-pine acres.

The Moravians, who immigrated from Austria, settled in the central piedmont of North Carolina around Winston-Salem. They were extremely interested in their forests and enacted forest management regulations and appointed foresters for their settlement as early as the 1750's. In October 1796, their records report the "loss of many pines near Hope" (Fries, 1943). Since this area has frequently been the center of southern pine beetle activity in North Carolina during the last several decades, it is probable that the dying trees were a result of beetle attack. It is significant that the report was entered in October which is one of the months in which beetle damage is most noticeable in North Carolina.

The Moravian report was followed by several reports of damage in the early 1800's that was most certainly southern pine beetle. F. Andrew Michaux reported dying longleaf pines in the coastal plain of Georgia and the Carolinas and yellow pine mortality in east Tennessee. His description leaves no doubt as to cause of mortality.

"...From the diversified uses of the wood, an idea may be formed of the consumption: to which may be added a waste of a more disasterous kind which seems impossible to arrest. Since the year 1804, extensive tracts of the finest pines are seen covered only with dead trees. In 1802, I remarked a similar phenomenon among the yellow pines in east Tennessee. This catastrophe is also felt among the Scotch firs which people the forests of the north of Europe and is wrought by swarms of small insects which lodge in different parts of the stock, insinuate themselves under the bark, penetrate into the body of the tree and cause it to perish in the course of a year" (Michaux, 1857).

The severity of the outbreak which was the subject of Michaux's report is further documented by contemporary South Carolina writers. The Charleston newspaper on January 7, 1804, reports: "It is now upwards of two years since it was observed that an unusual disease had made its appearance amongst the pine trees in the northern and eastern parts of this state...in many places there are thousands of acres where nine-tenths of the best trees are killed. The cause of the evil has been carefully sought after and found to proceed from a small black winged bug...No attempt has yet been made to remedy the evil which if it continues threatens to destroy the most valuable timber this country possesses. A gentleman lately from the county asserts that on a tract of two thousand acres of pine land which he owns on the Sampit River near Georgetown at least ninety trees in every hundred have been destroyed by this pernicious insect..."

John Drayton of Charleston in a letter to the American Philisophical Society dated October 9, 1803, reported the loss of hundreds of acres of pines on his plantation on the Santee River. His analysis of the problem shows some knowledge of the life cycle of the beetle. He reports, "...this mischief is affected by a bug which flying from tree to tree perforates a hole in the bark to the sap and lays an egg which in a little time originates a worm which feeding on the sap immeditely destroys the life of the tree (Drayton, 1803).

A letter from General Charles C. Pinckney read to the Philadelphia Philosophical Society on October 5, 1804, reported the formation of a committee by the South Carolina Agricultural Society to investigate the causes of the problem. No final report of the committee has been located, but this is probably the first attempt at

research on the southern pine beetle. He also states: "We are very uncertain whether the worms you allude to are the cause or the effect of the death of the trees..." (Pinckney, 1804).

Pinckney also commented on the strength and useability of recently killed timber and advocated its use. He predicted a short term market glut followed by shortages. In his letter, Pinckney illustrated the severity of the problem by reporting the loss of 5,000 acres of 7,000 acres on a plantation 26 miles north of Charleston.

James Madison in a letter to Judge Peters in 1818 said, "Now, all our red fields, long unplowed, are overspread with pines, as thick as they can grow; whilst the adjacent grey lands, originally clothed with a pine forest, are gradually losing that kind of tree under the depredation of a particular worm." This is the earliest recording of pine mortality in Virginia. It was probably southern pine beetle.

From the time of the first reports in the late 1700's and early 1800's until the late 1800's, there is very little information on the damage caused by the southern pine beetle. Although it is possible that no damage was incurred from the beetle during this time period, it is probable that damage was occurring but was not noted because of poor survey methods or indifference. Table 2 (See Appendix) is a brief summary of survey data that was available from 1882-1959.

It does not appear, as some writers have suggested, that outbreaks of southern pine beetle occur periodically with a dearth of

beetle activity between outbreaks. Some very severe outbreaks occur in the southeast almost every year (Figures 1-31). Periodically, the localized outbreaks combine to produce a southwide outbreak.

Beginning in the early 1960's, improved survey detection techniques and expanded pest control organizations allowed improved detection and damage data collection. Table 1 and Figures 1-31 summarize survey data collected since 1960.

HISTORY OF SOUTHERN PINE BEETLE CONTROL

The first attempts to control bark beetles were probably European and involved *Ips* spp. Disastrous bark beetle outbreaks occurred in Germany during the seventeenth and eighteenth centuries. So severe was the problem that a special prayer for the protection of forests from wind and insects was included in a prayer book printed in 1705. Gmelin (1787) reported that over a million-and-a-half trees were killed in the Hercynian Mountains alone between 1781 and 1787. Gmelin collected data from these seventeenth and eighteenth century outbreaks and in 1787 published a treatise on bark beetles. In addition to biological data, the treatise contained comprehensive detection and control recommendations. As a first step, Gmelin recommended an intensive survey to locate infested trees.

His major recommendation for beetle control was prompt salvage or burning of infested trees. Emphasis was placed on selecting trees still containing brood and ignoring trees from which beetles had already emerged. After trees were salvaged, bark removed from trees during the milling process was burned.

Gmelin also detailed the use of trap trees as a control measure. This consisted of cutting healthy trees at specified intervals. After the trees were attacked by beetles, they were burned to eliminate the brood.

In addition to direct control measures, Gmelin recommended thinning and sanitation measures to prevent attack. He also suggested that careless logging and weather and soil conditions may predispose stands to attack.

He astutely attempted to correlate resin flow of individual trees with attack success and suggested that seed from resistant trees be used to propagate future beetle resistant stands.

Gmelin reported that seventeenth and eighteenth century attempts to control beetles with chemicals were generally unsuccessful and were considered dangerous because of the available chemicals: arsenic, smoke of heather, sulphur and straw. He also toyed with the notion of using electricity for beetle control.

Gmelin looked at reasons for population collapse and attributed collapses to weather or to "the increasing number of enemies which limits unusual and tremendous overpopulation of the beetle". Although Gmelin's recommendations were made for an European species, we will see the same basic suggestions appear in American literature on southern pine beetle.

After the German control measures for bark beetles, the next attempt and probably the first in the United States was instigated by the Moravians in piedmont North Carolina (Fries et al., 1922). In 1797 they made a concerted attempt to salvage dead and dying beetle-attacked timber. Their salvage program appears to have been aimed more at loss minimization than at beetle control.

Hopkins (1909) observed an extensive southern pine beetle outbreak in Virginia and West Virginia in 1891-92. He recommended salvage with subsequent destruction of bark by burning as a control measure. He believed that control action would be most effective during the winter months when beetle development is slow. He suggested water immersion of bark as an alternative to burning.

Hopkins also made sanitation recommendations designed to minimize beetle problems. These included removal of lightning struck trees and restricting cutting to winter months in areas of known occurrence.

During an epidemic which occurred in North and South Carolina in 1911-1912, Hopkins' recommendations were used in organized control projects in Mecklenburg and Gaston counties, North Carolina (Pratt, 1912). In 1912 the U. S. Bureau of Entomology established a branch office in Spartanburg, South Carolina to supply technical expertise for support of the SPB control projects (Pratt, 1911).

The use of chemicals for SPB control has been investigated since the first quarter of the twentieth century. Surprisingly, a major investigation was made of systemic chemicals by U. S. Forest Service researchers in the 1920's and 30's. St. George and Caird (1929) and St. George and Huckenpahler (1933) injected a wide range of chemicals into SPB infested trees hoping to kill the insect brood. They found that denatured alcohol, wood alcohol, carbon bisulphide, ammonium fluoride, and hydrocyanic gas provided adequate brood control. Mercuris chloride, zinc chloride and zinc meta arsenite injections not only killed beetle brood, but were found to be good wood preservatives.

Chemically pure nicotine injected into recently-infested trees by U. S. Forest Service researchers in 1933 (Anon., 1933) was found to kill SPB without causing tree mortality. Eleven other materials were found either to kill host trees or were not effective agents for beetle control. Although several of the systemic chemicals appeared effective, subsequent research revealed that the chemicals must be

applied within five to seven days of attack to be successfully translocated (Craighead and St. George, 1938). After this time period the blue stain fungus blocks chemical movement. This information led to the abandonment of systemic use in the Southeast at that time.

The same research group used several chemicals to control SPB in logs. Stainless creosote, pine oil (termex) and a mixture of one part orthodichlorobenzene to ten parts kerosene were found to control brood. Spraying recently attacked standing trees failed to increase survival rates of the infested trees. St. George (1932) attempted to apply both kerosene and orthodichlorobenzene as a prophylactic measure. He hoped that these materials would repel attacks. While he thought that the orthodichlorobenzene treatment was effective, the kerosene was a failure.

Researchers at the Southern Forest Experiment Station tested benzene hexachloride (BHC), orthodichlorobenzene, chlordane, and DDT against SPB. BHC proved to be most effective and 0.5% BHC in fuel oil became the standard chemical for SPB control in the South. BHC was first recommended for SPB to combat a 1950 outbreak in east Texas (Billings, 1989). BHC was further tested in 1955 (Speers et al., 1955) and was found to be more effective than either ethylene dibromide or orthodichlorobenzene for beetle control. This further reinforced the use of BHC as the predominant chemical control agent in the southeast. Accordingly, BHC mixed as a 0.5 percent active ingredient in fuel oil was the principal, direct control method used throughout the South from 1959 through 1970.

Interest in systemics resurfaced when Ollieu (Ollieu 1969) investigated the use of cacodylic acid, a fast acting herbicide, and found successful brood reduction. From 1963-1974, Texas forest industry leaders organized and founded the Southern Forest Research Institute, under the direction of Dr. J. P. Vit. This Institute studied SPB attack behavior and infestation dynamics (Billings, 1989) and eventually isolated and identified several SPB behavioral chemicals, including frontalin, trans-verbenol and verbenone (Kinzer et al., 1969; Renwick, 1967). Alpha pinene and frontalin were subsequently mixed to form an attractant called frontalure. This was placed on cacodylic acid-treated trees in an attempt to trap and kill beetles in a single operation. A widespread test of the technique in Texas in 1970 met with variable success (Coulson et al., 1975) and the technique is no longer used. Research is still continuing toward developing new control tactics using SPB behavioral chemicals. In recent tests in several southern states, the beetle-produced inhibitor verbenone has been effectively used to halt spot growth without need for felling uninfested trees (Payne and Billings, 1989; Billings, 1990).

After comprehensive testing, the chemicals chlorpyrifos (Dursban 4E) and fenitrothion (Pestroy) were registered with the EPA in 1979 for both prophylactic and remedial treatment. These chemicals along with lindane are the chemicals currently registered (199) for SPB control.

In addition to chemical control, mechanical control has undergone an evolution since Gmelin recommended salvage and burning of infested material and Hopkins added water immersion.

During an outbreak in Texas in 1938-39, control consisted of cutting a half mile swath around the infested areas (Billings, 1989). By 1945, the recommendation for swath width had been reduced to a quarter mile. By the early 1960's, mechanical control recommendations consisted of salvage of actively infested trees plus a buffer strip to ensure that recently attacked trees would not be overlooked in the salvage operation. Thatcher, et al. (1982) summarized current salvage recommendations. Salvage remains the most recommended direct control method for treating SPB infestations (Swain and Remion, (1981).

In addition to salvage control, a second mechanical option is cut-and-leave (Billings, 1980). An early version of the cut-and-leave treatment was described by Patterson (1930) as the solar heat method. Originally, control consisted of felling and limbing trees. The boles were then exposed to the sun for a few days to kill brood and then the boles were rolled to expose the other side to the sun's rays. By 1969, Texas personnel had modified the technique (Ollieu, 1969) to take advantage of known limitations in SPB attack behavior. Actively-infested trees along with a 40-60 foot wide green buffer strip were simply felled and left in the forest. The treatment eliminates natural sources of attraction (pheromone production), causing emerging beetles to disperse (Billings, 1980). This was found to effectively halt spot growth, particularly when small spots (10-100 trees) were treated. Treatment of active SPB infestations by salvage or cut-and-leave during summer months in east Texas also was found to reduce the frequency of new spot proliferation in the vicinity of treated spots (Billings and Pase,

1979b). An analysis of cut and leave in the Georgia piedmont in 1980 was conducted by the Georgia Forestry Commission. Treatment effects were evaluated for ten replicates established in eight infestations. Nine of ten replicates showed a mean net reduction in brood production. Spot proliferation did not occur following cut and leave but SPB populations were clearly on the decline (GFC 1980).

Although the individual tactics currently used for direct control of SPB have been around for many decades, the rationale or general approach to suppression has been revised in recent decades. During the era of chemical insecticides (1950-1970), the goal of most state and federal forestry agencies in the South was to detect and chemically treat each and every suspected SPB infestation, regardless of its size. Clearly, the ultimate goal was to solve the pest problem by eradicating the insect, if at all possible. The Georgia Forestry Commission cut and sprayed over 1 million SPB infested trees in 1962 (GFC Internal Report 1963). Despite thousands of dollars of chemicals and countless manhours dedicated to suppression activities, the SPB problem persisted year after year.

Large scale insecticide control was voluntarily discontinued around 1970 due to the increasing cost of materials and persistence of the pest population. In addition, research findings by the Southern Forest Research Institute (Williamson and Vite, 1971) provided evidence that use of chemical treatments in east Texas may have contributed to the unprecedented 20-year SPB outbreak by selectively eliminating populations of natural enemies. Since 1970, mechanical control methods (salvage removal and cut-and-leave) have largely replaced insecticides in operational control programs.

The current control strategy no longer attempts to eradicate the beetle by treating all infestations, but focuses on those infestations likely to expand and cause the greatest resource losses. Accordingly, only multiple-tree infestations are recorded by aerial observers. Each spot that exceeds a detection threshold (5-10 trees) is assigned a ground-check priority, based on the presence and abundance of trees with freshly-fading crowns (Billings and Doggett, 1979). To aid ground-check crews, a field guide (Billings and Pase, 1979a) was developed for rating individual SPB infestations and assigning a control priority, based on the potential for expansion (Billings, 1979). For use in critical situations, spot growth models are now available to predict actual tree losses that will occur if no control is applied (Billings and Hynum, 1980; Stephen and Lih, 1985). Small, non-expanding spots are monitored from the ground or air until they go inactive, without need for control (Billings, 1979). This approach has greatly reduced work loads of control crews and increased the efficacy of control efforts.

Area-wide SPB control efforts have long been hampered by such factors as the multitude of small landowners, poor access, lack of markets for beetle-killed timber, and landowner apathy (Billings, 1980). In addition, new constraints have developed during the last decade to further limit the extent to which area-wide SPB outbreaks can be prevented or controlled. The establishment of wilderness areas in various southern states in recent years hinders area-wide control efforts. No direct control or preventive treatments are allowed in these areas unless the infestation occurs within one-fourth mile of the boundary, endangered species are threatened,

and/or several other specific criteria are met. As a result, these unmanaged areas have become increasingly prone to severe and persistent SPB outbreaks and threaten to become breeding grounds for perennial SPB populations.

Control efforts on certain National Forests are now routinely hampered by environmental activists who effectively use legal appeals and lawsuits to halt or delay suppression activities. The Four Notch experience in east Texas provides testimony to the destructive potential of SPB if no control is taken. Due to actions by environmentalists which caused delays in direct control, SPB infestations on this proposed wilderness area killed more than 2,000 acres of sawtimber in less than one year, drastically increased the frequency and severity of timber losses on adjacent commercial forest lands, and eliminated several colonies of the endangered red-cockaded woodpecker (Miles, 1987).

The 1988 court-mandated requirement to manage National Forest lands so as to promote survival of the red cockaded woodpecker may serve to aggravate the SPB problem. Rotation ages have been extended and hardwood mid-story trees eliminated in foraging areas and in colony sites; these manipulations may increase susceptibility to SPB infestations in the long run. Direct control may thus be required more frequently to protect cavity trees and critical foraging areas from SPB infestations.

Silvicultural methods have been recommended to prevent SPB damage. Beal and Massey (1945) recommended fire prevention, slash disposal, thinning, and regulating stand composition and density as beetle reduction measures. They also suggested shorter rotation

lengths as a measure to avoid beetle problems. Bennett (1971) made comprehensive silvicultural recommendations. These included increasing the resistance of stands by promoting rapid growth, avoiding unnecessary site and stand disturbance, sanitation cutting, particularly when lightning struck trees are involved and drainage to relieve soil moisture stress.

The Expanded Southern Pine Beetle Research and Applications Program (1974-1980) developed several hazard rating systems for SPB and identified further silvilcultural recommendations to minimize beetle damage (Thatcher, et al., 1980). The latter included favoring resistant species (slash, longleaf, Virginia and white pines over loblolly, shortleaf, or pitch), sanitation, maintaining rapid radial growth, promoting mixed hardwood-pine stands, minimizing logging damage, harvesting overmature stands, and site protection.

There has long been interest in biological control of bark beetles. Gmelin (1787) recognized the importance of natural control agents in the cyclic nature of bark beetle infestations. Although he indicated that "one may become suspicious that the reduction of such enemies...may be one of the causes of the tremendous overpopulations of bark beetles," he apparently did not try to supplement biological control factors.

Hopkins (1899) was a strong supporter of biological control of SPB. During an outbreak in Virginia, West Virginia, and Maryland in the latter part of the nineteenth century, he attemped biological control of the insect. He traveled to Germany and imported over 3,000 living specimens of a clerid beetle (Clerus formicarius) which he hoped would function as a biological control agent. These

were released at a number of SPB spots in West Virginia in 1892-1894. As with many other studies, shortly after Hopkins introduced this imported clerid, the SPB population collapsed. However, there is no evidence that this clerid became established as a result of these introductions. It is of interest that this collection of predators was largely financially supported by the timber companies in the stricken areas (as was the Southern Forest Research Institute in east Texas).

Although a substantial body of research exists on natural enemies of SPB, there has been surprisingly little research done on utilization of these natural control measures since Hopkins' early work. Some of the direct control measures currently used are timed to minimize impact on natural control factors, but otherwise there appears to be little interest in this potentially valuable area. The fact that SPB is a native insect has discouraged entomologists from pursuing this approach.

Although outbreaks of the southern pine beetle have been reported for several hundred years and extensive research and control efforts have been aimed at this small insect, it continues to be one of the most destructive pests of southern forests.

TABLE 1.--DAMAGE ESTIMATES OF SOUTHERN PINE BEETLE IN THE SOUTHEASTERN UNITED STATES, 1960-1990[1/]

STATE	CALENDAR YEAR [2/]	ESTIMATED VOLUME SALVAGED[3/] CORDS	ESTIMATED VOLUME SALVAGED[3/] MBF	ESTIMATED VOLUME NOT SALVAGED CORDS	ESTIMATED VOLUME NOT SALVAGED MBF	TOTAL VOLUME CORDS	KILLED MBF	STUMPAGE VALUES[4/] PULPWOOD $/CORDS	STUMPAGE VALUES[4/] SAWTIMBER $/MBF	TOTAL VALUE ($)
AL	1972	220,027	62,575	217,792	58,860	437,819	121,435	7.50	70	11,784,092
AL	1973	298,930	49,441	293,048	44,428	591,978	93,869	7.50	70	11,010,665
AL	1974	332,785	33,607	110,363	11,106	443,148	44,713	7.50	70	6,453,520
AL	1975	120,607	25,666	192,360	25,277	312,967	50,943	7.50	70	5,913,262
AL	1976	36,408	2,373	35,880	2,185	72,288	4,558	7.50	70	861,220
AL	1977	69	39	46	17	115	56	7.00	55	3,885
AL	1978	0	0	0	0	0	0	.00	0	0
AL	1979	326,590	31,282	489,885	43,646	816,475	74,928	15.75	172	25,747,097
AL	1980	487,839	15,278	487,114	14,489	974,953	29,767	16.00	110	18,873,618
AL	1981	1,992	150	1,992	150	3,984	300	17.00	157	114,828
AL	1982	4,597	1,500	4,397	600	8,994	2,100	17.00	152	472,098
AL	1983	15,396	1,999	13,688	3,619	29,084	7,618	17.00	178	1,850,432
AL	1984	1,183	0	3,421	658	4,604	658	18.00	166	193,416
AL	1985	39,857	9,686	30,797	3,428	70,654	13,114	19.00	143	3,217,728
AL	1986	152,705	17,874	64,309	5,124	217,014	22,998	19.00	142	7,388,982
AL	1987	38,651	7,882	57,331	5,113	95,982	12,995	16.00	131	3,238,057
AL	1988	55,123	7,918	123,689	4,481	178,812	12,399	15.00	146	4,492,434
AL	1989	2,067	2,819	10,335	1,151	12,402	3,970	15.37	146	770,238
AL	1990	2,117	412	10,589	501	12,706	913	20.17	152	395,056
AR	1973	1,700	504	5,100	1,512	6,800	2,016	7.00	90	229,040
AR	1974	1,600	336	4,800	1,000	6,400	1,336	7.00	90	165,040
AR	1975	3,800	642	7,600	1,284	11,400	1,926	7.00	90	253,140
AR	1976	13,000	21,988	6,500	10,000	19,500	31,988	7.00	90	3,015,420
AR	1977	7,399	18,137	1,029	517	8,428	18,654	6.25	122	2,328,463
AR	1978	1,166	123	400	40	1,566	163	7.85	140	35,113
AR	1979	10	10	300	5	310	15	9.00	170	5,340
AR	1980	0	30	0	5	0	35	10.00	141	4,935
AR	1981	0	0	0	0	0	0	11.50	190	0
AR	1982	1,083	690	1,050	445	2,133	1,135	14.00	170	222,812
AR	1983	0	1,120	0	0	0	1,120	15.50	182	203,840
AR	1984	0	0	100	10	100	10	17.00	176	3,460
AR	1985	12,440	7,380	3,110	4,920	15,550	12,300	13.00	140	1,924,150
AR	1986	24,600	28,600	2,500	3,000	27,100	31,600	12.50	175	5,868,750
AR	1987	7,900	7,003	1,000	1,000	8,900	8,003	13.00	175	1,516,225
AR	1988	5,820	2,046	750	880	6,570	2,926	14.00	167	580,622
AR	1989	800	822	250	200	1,050	1,022	13.25	160	177,433
AR	1990	25	376	50	191	75	567	12.00	180	102,960
FL	1972	0	0	10	50	10	50	15.00	50	2,650
FL	1973	50	55	0	0	50	55	10.00	50	3,250
FL	1974	550	2,000	0	0	550	2,000	10.00	50	105,500
FL	1975	2,002	0	0	0	2,002	0	10.00	50	20,020
FL	1976	260	0	0	0	260	0	20.00	50	5,200
FL	1977	89	269	38	115	127	384	7.00	55	22,009
FL	1978	0	0	0	0	0	0	.00	0	0
FL	1979	0	0	800	0	800	0	18.50	148	14,800
FL	1980	3,100	90,000	0	0	3,100	90,000	24.00	96	8,714,400
FL	1981	0	0	0	0	0	0	.00	0	0
FL	1982	0	0	0	0	6,603	0	.00	0	392,120

TABLE 1.--DAMAGE ESTIMATES OF SOUTHERN PINE BEETLE IN THE SOUTHEASTERN UNITED STATES, 1960-1990

STATE	CALENDAR YEAR	ESTIMATED VOLUME SALVAGED CORDS	ESTIMATED VOLUME SALVAGED MBF	ESTIMATED VOLUME NOT SALVAGED CORDS	ESTIMATED VOLUME NOT SALVAGED MBF	TOTAL VOLUME CORDS	KILLED MBF	STUMPAGE VALUES PULPWOOD $/CORDS	STUMPAGE VALUES SAWTIMBER $/MBF	TOTAL VALUE ($)
FL	1983	0	0	0	0	2,855	99	.00	0	28,000
FL	1984	0	0	0	0	100	0	.00	0	2,100
FL	1985	0	0	0	0	9,360	0	.00	0	240,000
FL	1986	0	0	0	0	5,170	0	.00	0	155,100
FL	1987	0	0	0	0	4,250	0	.00	0	136,000
FL	1988	0	0	0	0	0	0	.00	0	0
FL	1989	0	0	50	0	50	0	24.00	0	1,200
FL	1990	500	0	125	0	625	0	25.00	0	3,125
GA	1962	0	0	1,785,240 5/	958	1,785,240 5/	958	5.00	40	8,964,520
GA	1972	13,976	10,532	21,860	1,095	35,836	11,627	6.00	65	970,771
GA	1973	124,527	20,904	265,213	39,900	389,740	60,804	6.00	65	6,290,700
GA	1974	179,736	22,386	222,518	21,314	402,254	43,700	10.00	70	7,081,540
GA	1975	46,413	7,441	6,252	202	52,665	7,643	15.00	70	1,324,985
GA	1976	15,609	3,446	6,068	775	21,677	4,221	15.00	70	620,625
GA	1977	5,614	481	10,301	155	15,915	636	15.00	107	306,777
GA	1978	1,682	180	4,805	402	6,487	582	16.00	118	172,468
GA	1979	390,285	71,592	152,706	33,462	542,991	105,054	18.00	147	25,216,776
GA	1980	384,194	57,169	144,122	21,406	528,316	78,575	21.00	110	19,737,886
GA	1981	3,475	29	1,489	12	4,964	41	18.00	140	95,092
GA	1982	16,611	1,559	8,953	460	25,564	2,019	21.00	155	849,789
GA	1983	8,193	9,334	5,462	65	13,655	9,399	19.00	160	1,763,285
GA	1984	3,726	0	18,192	0	21,918	0	20.00	0	438,360
GA	1985	47,274	7,101	70,911	3,986	118,185	11,087	26.00	163	4,879,991
GA	1986	150,199	18,530	169,521	4,243	319,720	22,773	20.00	144	9,673,712
GA	1987	4,573	10,614	16,213	3,404	20,786	14,018	15.00	142	2,302,346
GA	1988	206,675	8,376	691,912	7,000	898,587	15,376	13.00	158	14,111,039
GA	1989	45,548	28	73,822	4	119,370	32,521	24.89	153	8,405,832
GA	1990	6,322	6,524	35,824	1,731	42,146	8,255	33.50	193	3,005,106
KY	1976	206	1,734	0	1,000	206	2,734	3.00	15	41,628
KY	1977	1,112	1,523	741	1,015	1,853	2,538	3.00	53	139,800
LA	1971	9,094	8,995	9,094	8,995	18,188	17,990	6.00	100	1,908,128
LA	1972	44,272	33,417	42,441	25,201	86,713	58,618	6.00	100	6,382,078
LA	1973	13,269	4,332	9,387	2,687	22,656	7,019	6.00	100	837,836
LA	1974	4,238	4,417	1,799	1,257	6,037	5,674	6.00	100	603,622
LA	1975	6,567	3,628	4,658	2,009	11,225	5,637	6.00	100	631,050
LA	1976	27,537	10,854	21,414	5,879	48,951	16,733	6.00	100	1,967,006
LA	1977	31,252	6,942	7,341	5,870	38,593	12,812	7.30	125	1,883,228
LA	1978	844	659	576	330	1,420	989	8.00	137	146,853
LA	1979	600	3,300	600	3,800	1,200	7,100	8.75	160	1,146,500
LA	1980	371	76	38	38	409	114	9.30	155	21,473
LA	1981	44	10,300	1,897	0	1,941	10,300	10.20	212	21,982
LA	1982	20,323	5,279	6,634	2,366	26,557	7,645	13.00	224	2,057,721
LA	1983	8,050	7,903	4,000	4,500	12,050	12,403	15.00	164	2,214,842
LA	1984	7,339	18,603	6,000	5,600	13,339	24,203	17.00	176	4,486,491
LA	1985	550,199	473,857	360,000	202,951	910,199	676,808	18.00	188	143,623,486
LA	1986	355,238	335,015	224,362	59,129	579,600	394,144	17.50	142	66,111,448

TABLE 1.--DAMAGE ESTIMATES OF SOUTHERN PINE BEETLE IN THE SOUTHEASTERN UNITED STATES, 1960-1990

STATE	CALENDAR YEAR	ESTIMATED VOLUME SALVAGED CORDS	ESTIMATED VOLUME SALVAGED MBF	ESTIMATED VOLUME NOT SALVAGED CORDS	ESTIMATED VOLUME NOT SALVAGED MBF	TOTAL VOLUME CORDS	TOTAL VOLUME KILLED MBF	STUMPAGE VALUES PULPWOOD $/CORDS	STUMPAGE VALUES SAWTIMBER $/MBF	TOTAL VALUE ($)
LA	1987	24,000	11,670	48,000	9,500	72,000	21,170	17.00	120	3,764,400
LA	1988	2,000	1,113	4,700	1,154	6,700	2,267	13.00	145	415,815
LA	1989	0	675	0	102	8,450	2,467	17.00	170	563,040
LA	1990	0	483	0	121	5,000	1,604	17.00	170	357,680
MS	1971	0	3,000	0	0	0	3,000	.00	50	150,000
MS	1972	537	7,172	0	0	537	7,172	6.00	50	361,822
MS	1973	579	7,229	0	0	579	7,229	8.00	50	366,082
MS	1974	329	7,474	0	0	329	7,474	8.00	50	376,332
MS	1975	488	9,600	0	0	488	9,600	8.00	60	579,904
MS	1976	4,023	16,949	5,800	21,000	9,823	37,949	9.00	60	2,365,347
MS	1977	8,597	8,651	4,812	7,019	13,409	15,670	8.00	115	1,909,322
MS	1978	2,267	4,093	5,920	3,960	8,187	8,053	5.25	140	1,170,402
MS	1979	40,246	13,799	68,294	15,985	108,540	29,784	9.00	155	5,593,380
MS	1980	77,630	34,137	113,002	64,796	190,632	98,933	11.00	128	14,760,376
MS	1981	638	8	57,482	5,979	58,120	5,987	11.50	203	1,883,741
MS	1982	1,293	8,098	22,094	6,422	23,387	14,520	12.00	163	2,647,404
MS	1983	5,147	3,654	11,300	5,279	16,447	8,933	12.50	174	1,759,930
MS	1984	360	12,039	2,087	813	2,447	12,852	12.50	167	2,176,872
MS	1985	8,892	44,449	40,507	24,918	49,399	69,367	12.75	160	11,728,557
MS	1986	39,403	49,298	116,668	35,309	156,071	84,607	12.00	172	16,425,256
MS	1987	9,804	23,005	102,563	12,533	112,367	35,238	12.25	184	7,860,288
MS	1988	15,537	9,494	18,132	11,237	33,669	20,731	12.00	187	4,280,725
MS	1989	3,468	7,143	8,179	2,985	11,647	10,128	11.50	188	2,038,004
MS	1990	529	1,140	545	499	1,074	1,639	18.25	257	440,823
NC	1960	0	0	0	200	0	200	5.00	35	7,000
NC	1961	0	0	0	5	0	5	5.00	35	175
NC	1962	10,000	5,000	10,000	5,000	20,000	10,000	5.00	35	450,000
NC	1963	20,408	10,121	3,600	1,800	24,008	11,921	5.00	35	537,275
NC	1964	5,565	4,740	1,000	1,000	6,565	5,740	5.00	35	233,725
NC	1965	28,108	19,281	15,000	12,000	43,108	31,281	5.00	40	1,466,780
NC	1966	28,758	26,485	4,000	3,000	32,758	29,485	5.00	40	1,343,190
NC	1967	2,876	2,008	2,000	1,500	4,876	3,508	5.00	40	164,700
NC	1968	26,037	10,776	30,000	10,000	56,037	20,776	5.00	40	1,111,225
NC	1969	35,867	15,197	30,000	15,000	65,867	30,197	5.00	40	1,537,215
NC	1970	26,579	16,558	25,000	15,000	51,579	31,558	5.00	40	1,520,215
NC	1971	6,388	600	1,000	10	7,388	610	5.00	45	64,390
NC	1972	31,415	8,622	1,200	2,500	32,615	11,122	6.00	80	1,085,450
NC	1973	79,414	41,573	59,200	32,000	138,614	73,573	6.00	80	6,717,524
NC	1974	198,331	82,949	155,000	65,000	353,331	147,949	6.00	50	9,517,436
NC	1975	213,004	92,160	188,000	72,000	401,004	164,160	6.00	50	10,614,024
NC	1976	77,615	26,248	25,549	8,523	103,164	34,771	6.00	50	2,357,534
NC	1977	53,665	6,169	25,075	3,026	78,740	9,195	7.35	100	1,498,239
NC	1978	37	0	500	20	537	20	7.25	97	5,833
NC	1979	1,578	589	62,834	38,330	64,416	38,919	7.50	140	5,931,780
NC	1980	5,815	1,354	236,007	57,412	241,822	58,766	7.50	105	7,984,095
NC	1981	1,185	307	600	0	1,785	307	8.00	152	60,944
NC	1982	32	7	85	0	117	7	9.00	134	1,991
NC	1983	128	67	390	0	518	67	9.00	155	15,047

TABLE 1.--DAMAGE ESTIMATES OF SOUTHERN PINE BEETLE IN THE SOUTHEASTERN UNITED STATES, 1960-1990

STATE	CALENDAR YEAR	ESTIMATED VOLUME SALVAGED CORDS	ESTIMATED VOLUME SALVAGED MBF	ESTIMATED VOLUME NOT SALVAGED CORDS	ESTIMATED VOLUME NOT SALVAGED MBF	TOTAL VOLUME CORDS	KILLED MBF	STUMPAGE VALUES PULPWOOD $/CORDS	STUMPAGE VALUES SAWTIMBER $/MBF	TOTAL VALUE ($)
NC	1984	151	51	1,500	0	1,651	51	10.00	155	24,415
NC	1985	1	0	50	0	51	0	10.00	132	510
NC	1986	401	371	600	66	1,001	437	11.40	133	69,532
NC	1987	25,094	8,219	30,000	1,506	55,094	9,725	11.50	127	1,868,656
NC	1988	3,148	4,766	3,500	3,003	6,648	7,769	11.72	121	1,017,964
NC	1989	5,192	12,585	75,068	23,095	80,260	35,630	11.38	132	5,617,366
NC	1990	5,485	13,636	2,742	4,119	8,227	17,755	12.79	140	2,590,969
SC	1960	0	390	0	3,510	0	3,900	.00	32	124,800
SC	1961	0	221	0	1,989	0	2,210	.00	34	75,140
SC	1962	11,400	400	31,600	89,600	43,000	90,000	5.00	36	3,455,000
SC	1963	250	324	1,400	1,838	1,650	2,162	7.00	32	80,734
SC	1964	50	46	310	409	360	455	7.00	32	17,080
SC	1967	834	701	7,506	6,308	8,340	7,009	7.00	37	317,713
SC	1968	1,352	1,009	12,165	9,084	13,517	10,093	7.00	40	498,339
SC	1969	1,604	629	14,440	5,663	16,044	6,292	6.00	35	316,484
SC	1971	400	30	1,070	112	1,470	142	6.00	30	13,080
SC	1972	15,500	7,918	234,500	4,300	250,000	12,218	7.00	52	2,385,336
SC	1973	120,135	7,640	164,200	116,800	284,335	124,440	8.00	89	13,349,840
SC	1974	193,310	16,911	54,000	97,630	247,310	114,541	7.00	70	9,749,040
SC	1975	85,214	10,606	0	20,629	85,214	31,235	7.00	60	2,470,598
SC	1976	19,274	510	0	0	19,274	510	7.00	60	165,518
SC	1977	236	25	157	17	393	42	7.00	54	5,000
SC	1978	0	0	0	0	0	0	.00	0	0
SC	1979	41,800	6,722	5,015	21,288	46,815	28,010	12.00	160	5,043,380
SC	1980	173,095	1,474	11,004	22,112	184,099	23,586	13.00	106	4,893,403
SC	1981	142,296	977	0	48,050	100,858	49,024	11.00	100	6,018,966
SC	1982	3,422	6	11,560	8,559	14,982	8,565	12.00	100	1,036,284
SC	1983	38,420	2,781	0	10,672	9,594	13,453	12.00	150	2,133,078
SC	1984	31,236	90	0	0	31,236	90	12.00	150	388,332
SC	1985	48,968	4,887	13,296	44,371	62,264	49,258	12.00	150	8,135,868
SC	1986	46,693	7,117	39,970	61,228	86,663	68,345	12.00	150	11,291,706
SC	1987	0	400	5,958	3,920	5,958	4,320	12.00	150	719,496
SC	1988	12,698	1,325	53,822	32,749	66,520	34,074	15.00	150	6,108,900
SC	1989	1,995	2,080	10,848	6,267	12,843	8,377	15.00	150	1,449,264
SC	1990	8,625	385	18,540	262	27,165	647	15.00	150	25,899,449
TN	1972	0	128	0	109	0	237	.00	25	5,925
TN	1973	1,567	386	438	0	2,005	386	6.00	30	23,610
TN	1974	10,465	1,857	693	324	11,158	2,181	6.00	35	143,283
TN	1975	19,967	5,587	419,600	103,659	439,567	109,246	3.00	30	4,596,081
TN	1976	5,974	3,830	37,644	20,397	43,618	24,227	6.00	30	988,518
TN	1977	659	651	1,486	214	2,145	865	5.83	48	54,025
TN	1978	0	0	19	29	19	29	6.00	65	1,999
TN	1979	0	204	38	29	38	233	5.75	66	15,596
TN	1980	105	2,548	217	217	322	2,765	5.25	52	145,470
TN	1981	0	0	17	3	17	3	5.50	65	289
TN	1982	0	0	10	10	10	10	3.00	58	610
TN	1983	0	0	20	95	20	95	7.50	101	9,745
TN	1984	0	0	4	45	4	45	7.50	101	4,575

TABLE 1.--DAMAGE ESTIMATES OF SOUTHERN PINE BEETLE IN THE SOUTHEASTERN UNITED STATES, 1960-1990

STATE	CALENDAR YEAR	ESTIMATED VOLUME SALVAGED CORDS	ESTIMATED VOLUME SALVAGED MBF	ESTIMATED VOLUME NOT SALVAGED CORDS	ESTIMATED VOLUME NOT SALVAGED MBF	TOTAL VOLUME CORDS	TOTAL VOLUME KILLED MBF	STUMPAGE VALUES PULPWOOD $/CORDS	STUMPAGE VALUES SAWTIMBER $/MBF	TOTAL VALUE ($)
TN	1985	0	0	0	1	0	1	8.75	74	74
TN	1986	900	21	1,103	1,403	2,003	1,424	8.50	90	145,186
TN	1987	913	1,898	4,557	4,212	5,470	6,110	9.15	63	434,981
TN	1988	4,736	2,362	15,841	6,869	20,577	9,231	10.67	64	810,341
TN	1989	963	2,594	2,890	1,431	3,853	4,025	10.50	79	358,440
TN	1990	16	751	64	214	80	965	9.50	64	62,555
TX	1960	3,648	3,744	4,352	4,256	8,000	8,000	3.54	27	248,959
TX	1961	10,944	8,371	13,056	9,516	24,000	17,887	3.54	19	441,269
TX	1962	50,666	43,544	60,444	49,499	111,110	93,043	3.54	19	2,246,745
TX	1963	876	1,911	1,044	2,173	1,920	4,084	3.54	18	84,066
TX	1964	648	1,170	772	1,331	1,420	2,501	3.54	21	58,673
TX	1965	3,531	1,777	4,212	2,020	7,743	3,797	3.54	25	122,487
TX	1966	3,160	2,928	3,770	3,328	6,930	6,256	4.09	30	220,027
TX	1967	3,906	3,367	4,660	3,827	8,566	7,194	4.09	30	255,459
TX	1968	10,049	8,257	11,988	9,387	22,037	17,644	4.09	33	684,734
TX	1969	3,410	3,436	4,068	3,905	7,478	7,341	4.09	40	326,867
TX	1970	6,717	2,021	8,013	2,297	14,730	4,318	4.09	34	208,094
TX	1971	30,521	1,812	36,412	2,062	66,933	3,872	4.09	38	424,105
TX	1972	25,528	15,013	27,414	13,146	52,942	28,159	4.09	47	1,553,803
TX	1973	21,973	30,047	28,327	18,607	50,300	48,654	4.23	62	3,241,480
TX	1974	42,497	45,219	21,346	22,446	63,843	67,665	4.81	57	4,216,768
TX	1975	16,750	15,661	19,826	30,262	36,576	45,923	5.22	66	3,258,123
TX	1976	98,840	131,614	123,544	98,172	222,384	229,786	6.15	72	18,139,741
TX	1977	41,636	35,814	29,512	22,660	71,148	58,474	6.50	110	6,894,602
TX	1978	138	634	262	408	400	1,042	7.35	135	143,610
TX	1979	0	1,311	201	25	201	1,336	9.00	175	235,608
TX	1980	0	50	2	5	2	55	9.25	160	8,818
TX	1981	0	0	0	0	0	0	.00	0	0
TX	1982	1,657	3,780	33	124	1,690	3,904	16.00	160	651,680
TX	1983	2,218	8,065	545	15,772	2,763	23,837	16.00	150	3,619,758
TX	1984	34,688	74,030	12,277	17,921	46,965	91,951	16.00	140	13,624,580
TX	1985	135,028	363,196	97,583	108,310	232,611	471,506	18.00	125	63,125,248
TX	1986	42,550	42,096	95,676	38,281	138,199	80,377	13.00	115	11,039,942
TX	1987	785	3,200	1,830	899	2,615	4,099	15.00	115	510,610
TX	1988	653	1,976	1,598	784	2,251	2,760	15.00	130	392,565
TX	1989	4,162	35,599	1,770	6,873	5,932	33,472	18.00	156	6,732,408
TX	1990	1,679	11,654	2,132	4,219	3,829	15,873	22.00	163	2,671,537
VA	1961	18,000	0	12,000	0	30,000	0	5.00	0	150,000
VA	1964	63,000	0	27,000	0	90,000	0	6.00	0	540,000
VA	1970	0	9,000	0	6,000	0	15,000	.00	40	600,000
VA	1972 6/	4,843	14,485	1,403	13,956	6,247	28,441	6.00	40	1,175,122
VA	1973	4,843	14,485	1,403	13,956	6,247	28,441	6.00	40	1,175,122
VA	1974	4,843	14,485	1,403	13,956	6,247	28,441	6.00	40	1,175,122
VA	1975	4,843	14,485	1,403	13,956	6,247	28,441	6.00	40	1,175,122
VA	1976	4,843	14,485	1,403	13,956	6,247	28,441	6.00	40	1,175,122
VA	1977	159	0	106	0	265	0	6.79	0	1,800
VA	1979	50	0	150	0	200	0	6.70	91	1,339
VA	1980	90	0	299	0	389	0	8.25	69	3,209

TABLE 1.--DAMAGE ESTIMATES OF SOUTHERN PINE BEETLE IN THE SOUTHEASTERN UNITED STATES, 1960-1990

STATE	CALENDAR YEAR	ESTIMATED VOLUME SALVAGED CORDS	MBF	ESTIMATED VOLUME NOT SALVAGED CORDS	MBF	TOTAL VOLUME CORDS	KILLED MBF	STUMPAGE VALUES PULPWOOD $/CORDS	SAWTIMBER $/MBF	TOTAL VALUE ($)
VA	1981	500	30	200	20	700	50	9.00	100	11,300
VA	1982	210,000	33,200	200,000	13,000	410,000	46,200	9.00	120	9,234,000
VA	1983	7,100	22,200	6,400	14,800	13,500	37,000	9.00	125	4,746,500
VA	1984	3,200	4,200	2,400	3,700	5,600	7,900	10.00	100	846,000
VA	1985	410	57	500	30	910	87	10.00	100	17,800
VA	1986	4,417	1,036	3,276	267	7,693	1,303	11.00	110	227,953
VA	1987	5,075	1,006	4,675	947	9,750	1,953	11.00	125	351,375
VA	1988	522	63	200	30	722	93	11.00	125	19,567
VA	1989	20	20	30	10	50	30	12.00	125	4,350
VA	1990	50	50	70	20	120	70	120.00	125	10,190

1/ Information collected from each state and federal pest control specialist.
2/ Beginning year is based on available state records.
3/ Includes estimates on federal, state, and private lands.
4/ Stumpage prices are estimates from each state pest specialist, and the same values are assigned to timber salvaged and not salvaged.
5/ Actual volume of timber chemically treated plus estimated volume killed with no treatment.
6/ A total of 31,230 cords and 142,205 MBF was reported killed from 1972-1976. To provide uniformity within the table, these figures were divided by 5 years to show an average by year.

CORRECTIONS

The outbreak status of the following counties were incorrectly mapped. Their coloring should be changed to the color shown.

Figure	Year	County	Correct Color
30	1989	Hempstead County, Arkansas	Green
30	1989	Miller County, Arkansas	Green
30	1989	Nevada County, Arkansas	Green
31	1990	Hempstead County, Arkansas	Green
31	1990	Little River County, Arkansas	Green

Figure 1

Location of southern pine beetle infestations in the Southeast

1960

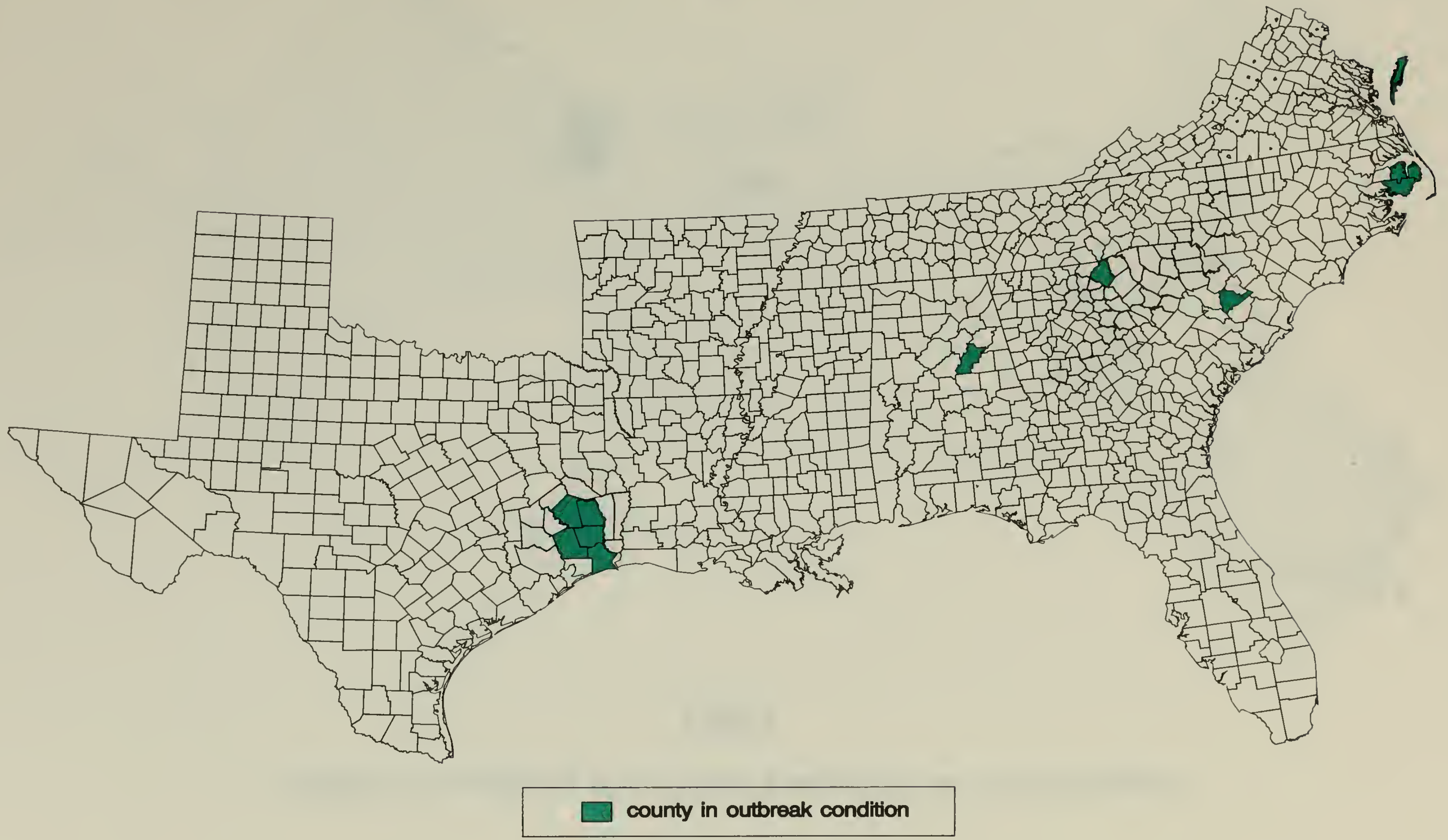


Figure 2

Location of southern pine beetle infestations in the Southeast

1961

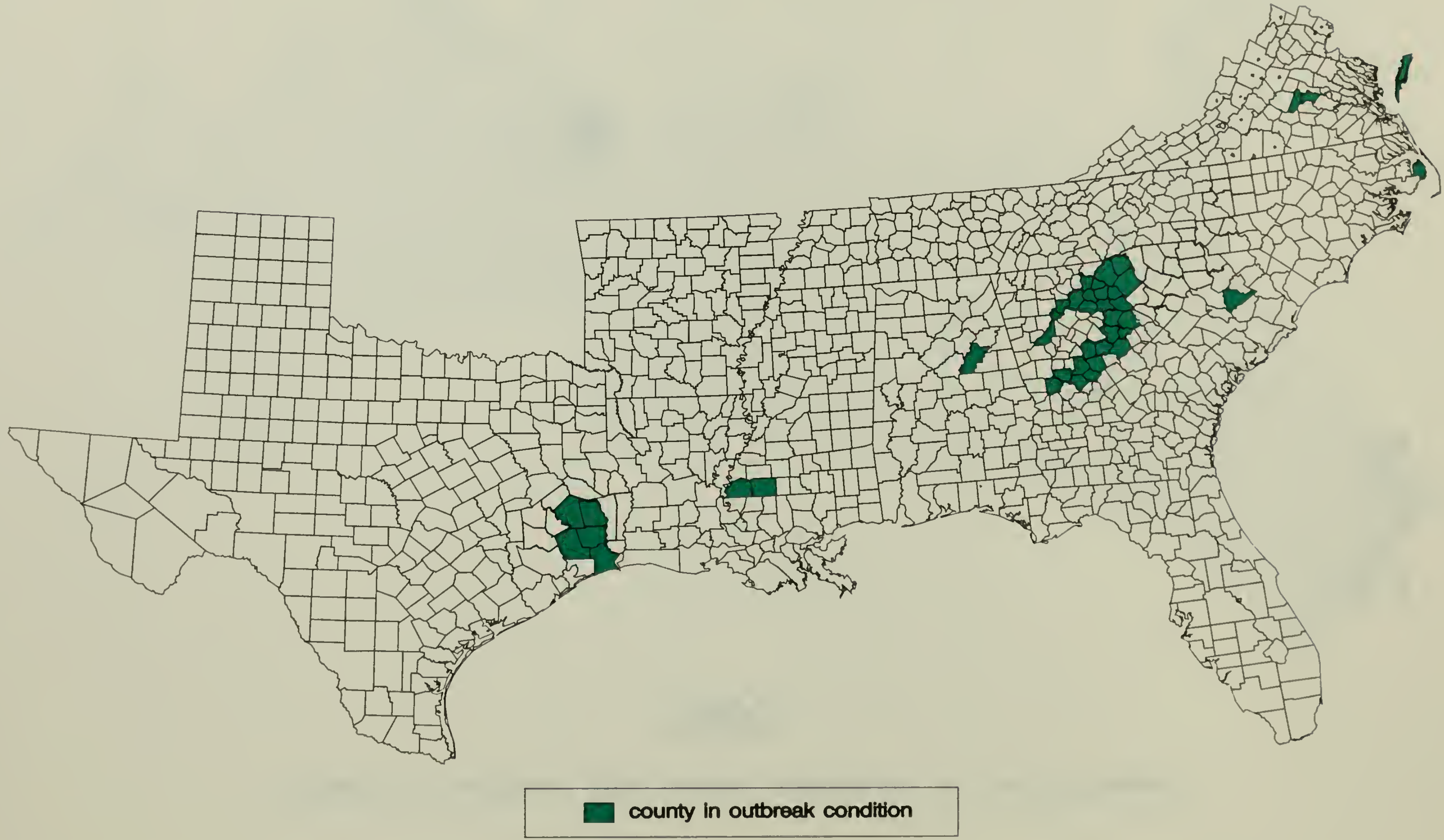


Figure 3

Location of southern pine beetle infestations in the Southeast

1962

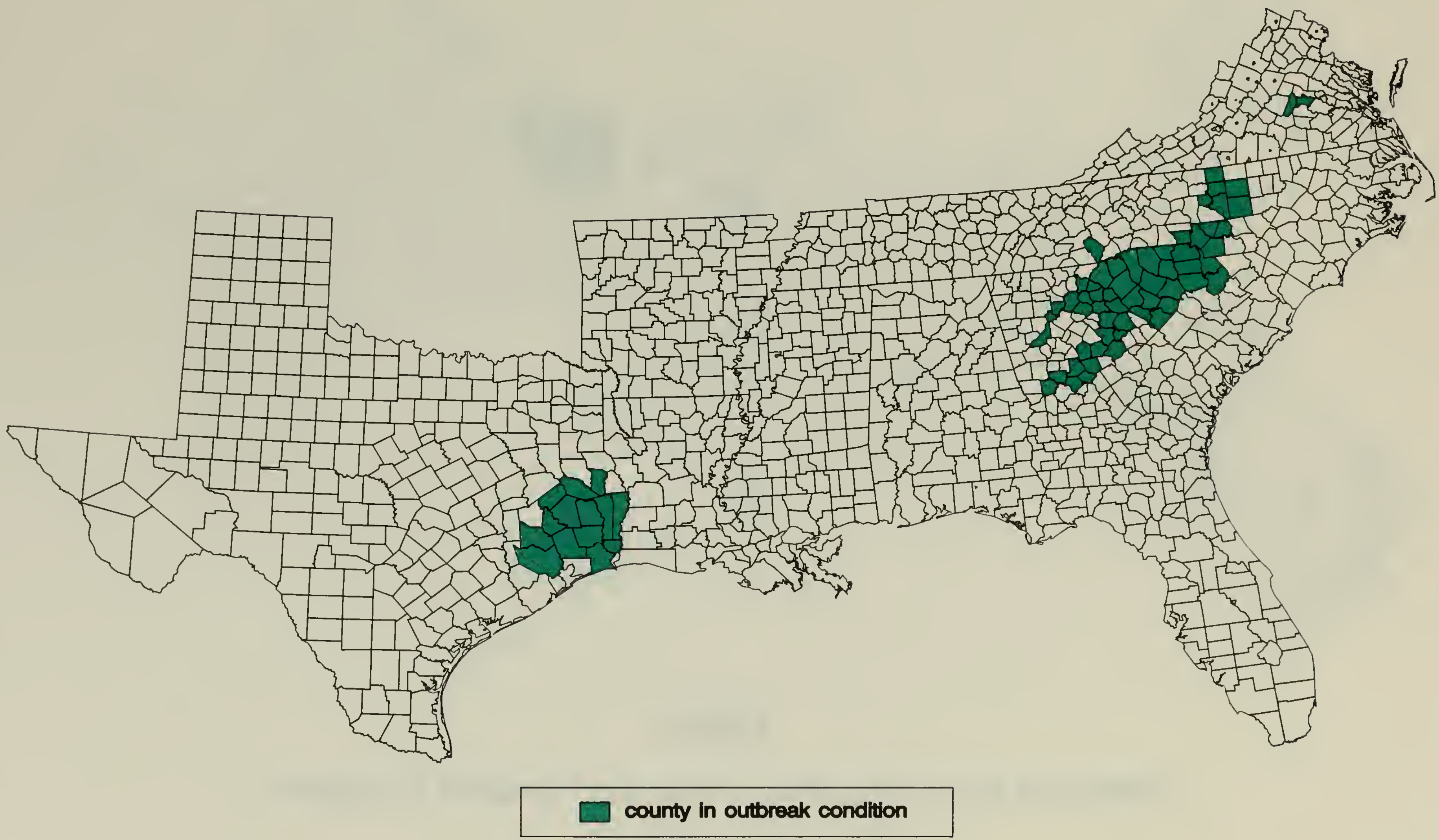


Figure 4

Location of southern pine beetle infestations in the Southeast

1963

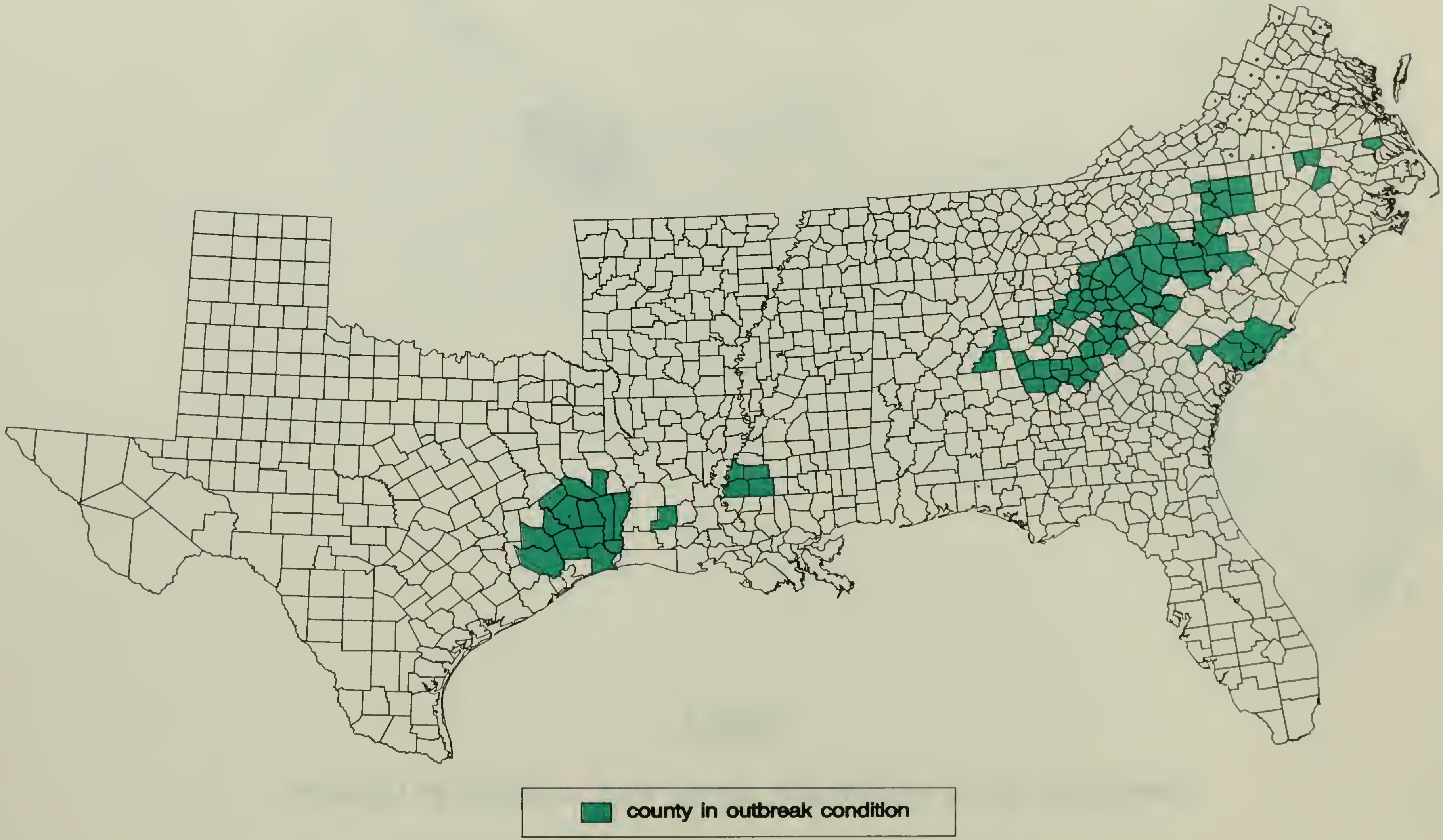


Figure 5

Location of southern pine beetle infestations in the Southeast

1964

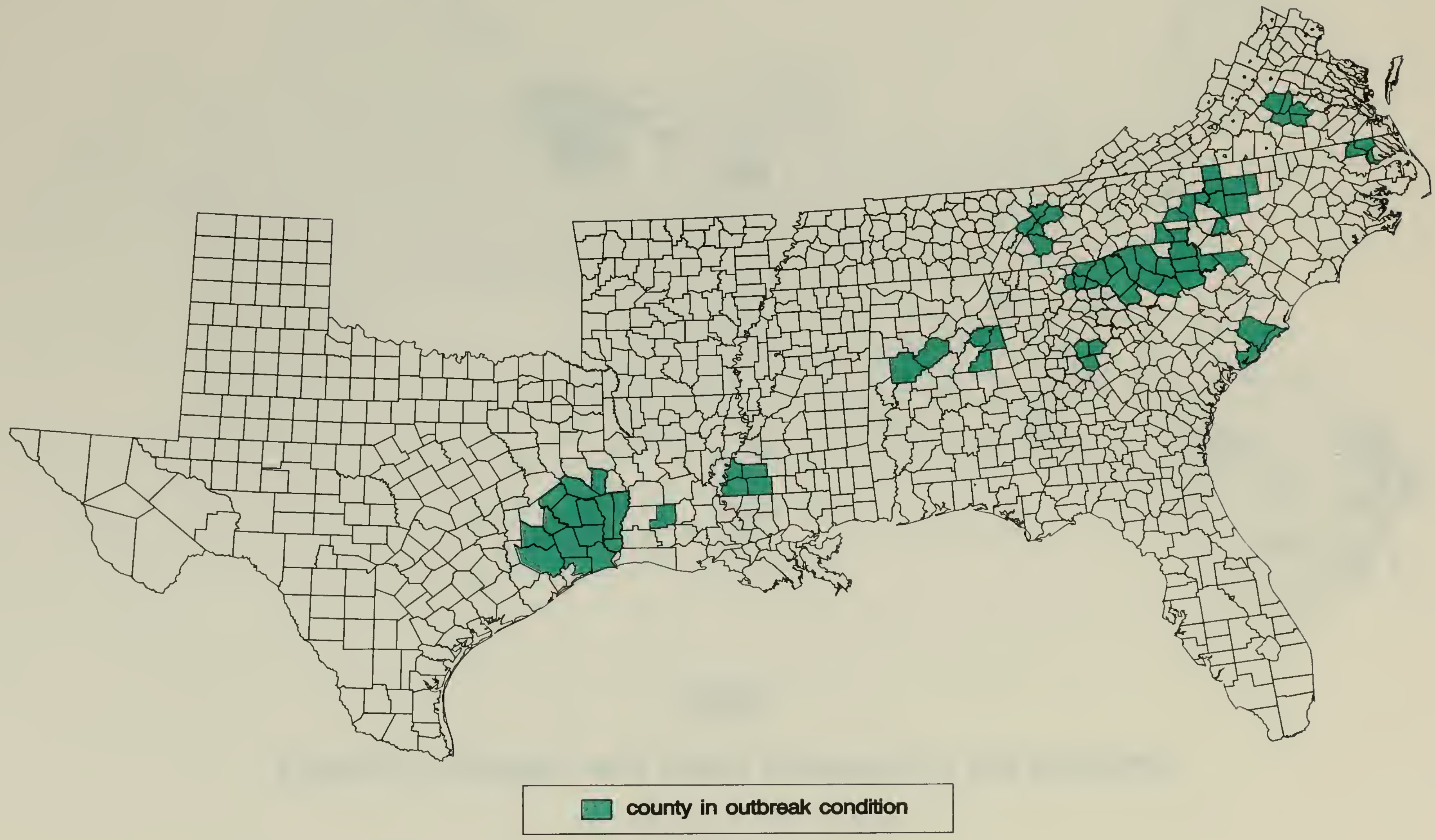


Figure 6

Location of southern pine beetle infestations in the Southeast

1965

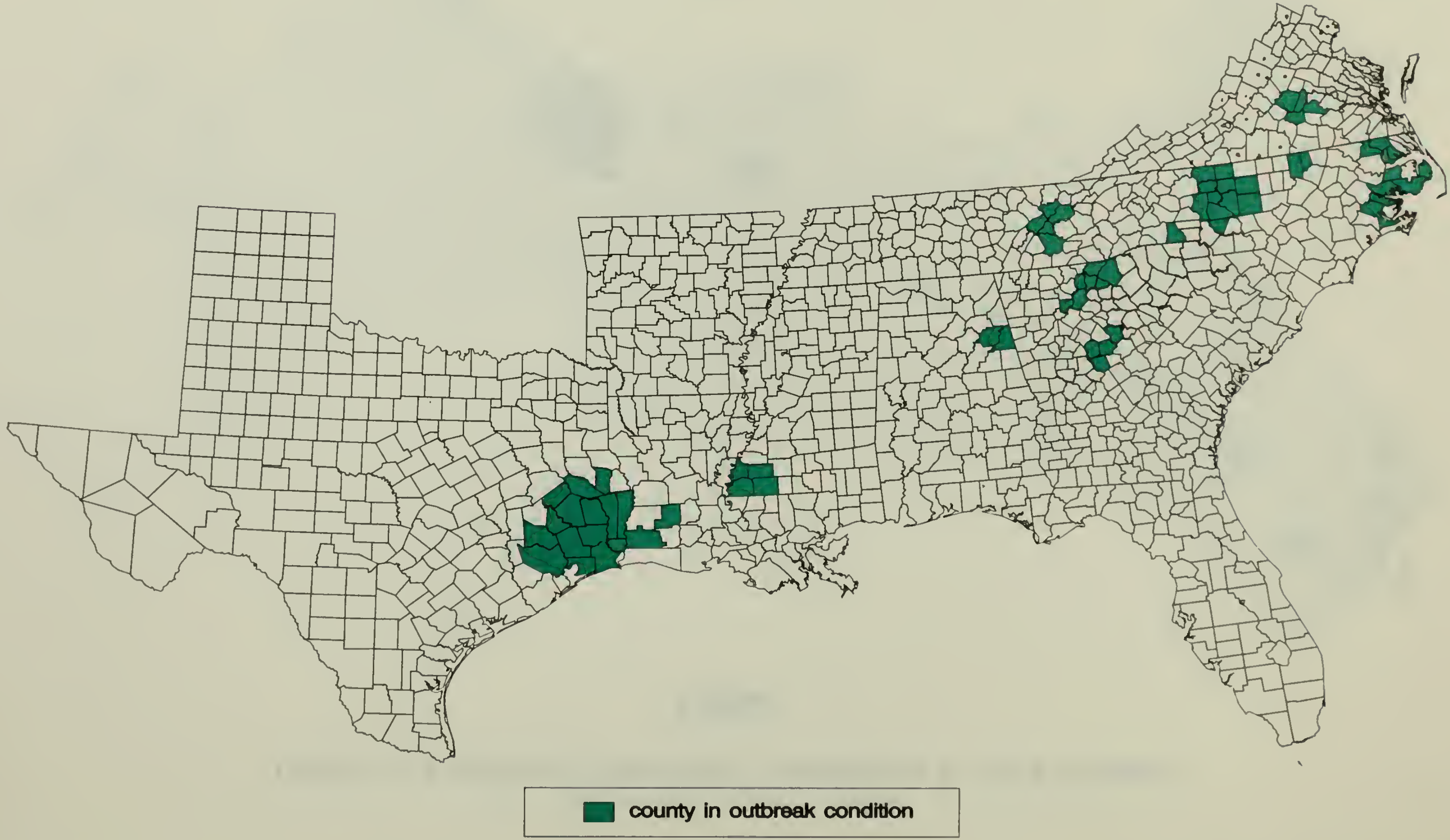


Figure 7

Location of southern pine beetle infestations in the Southeast

1966

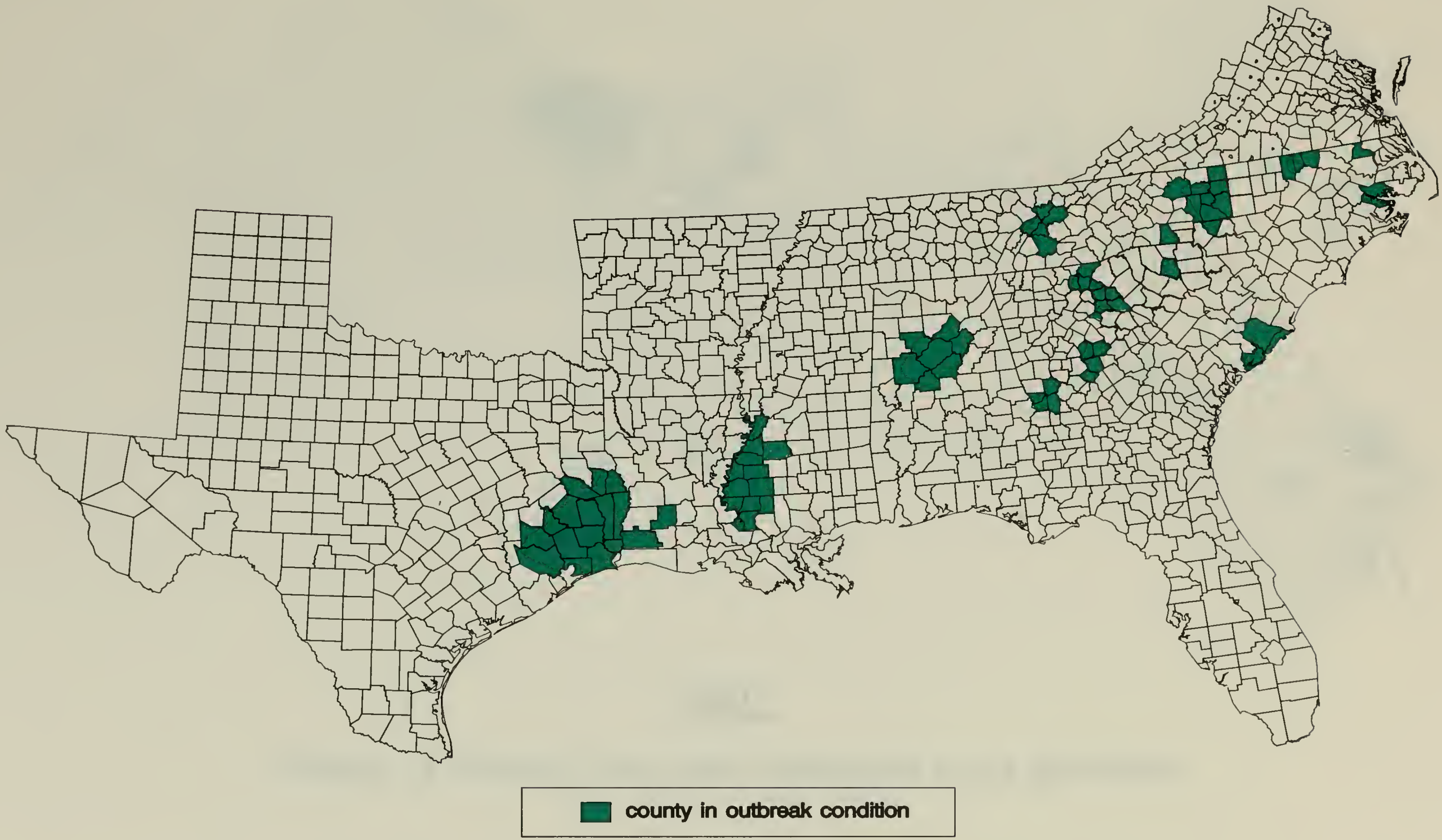


Figure 8

Location of southern pine beetle infestations in the Southeast

1967

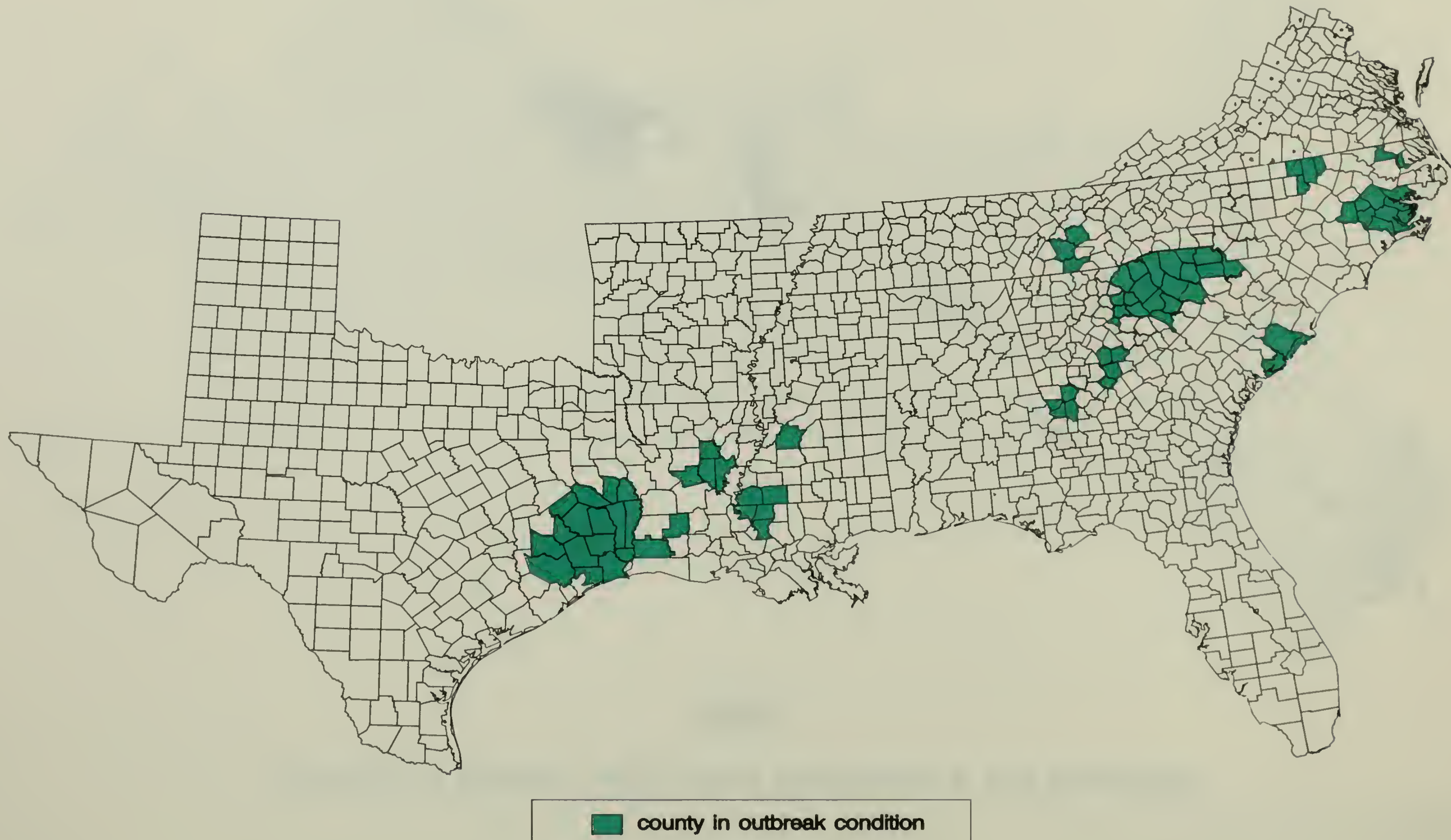


Figure 9

Location of southern pine beetle infestations in the Southeast

1968

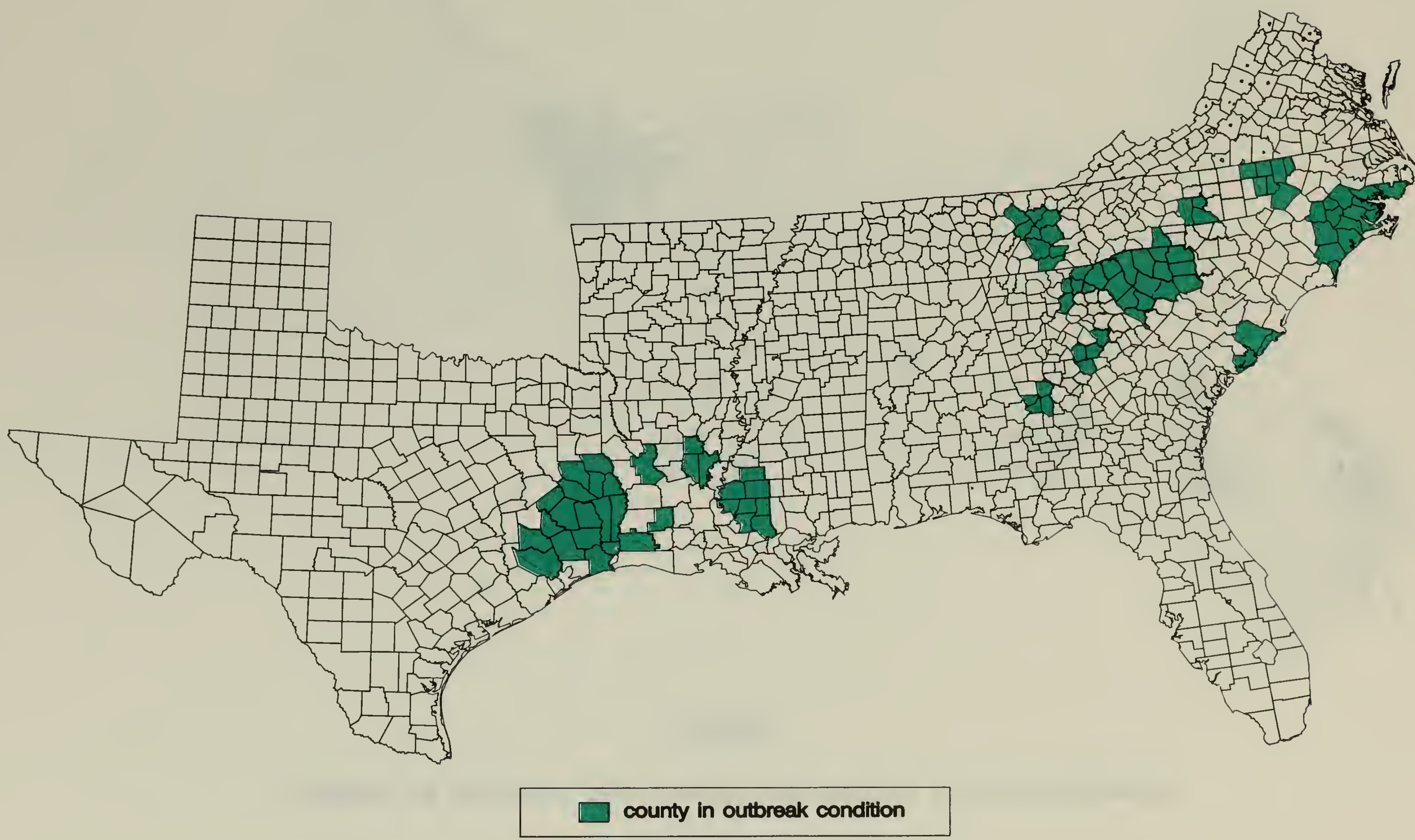


Figure 10

Location of southern pine beetle infestations in the Southeast

1969

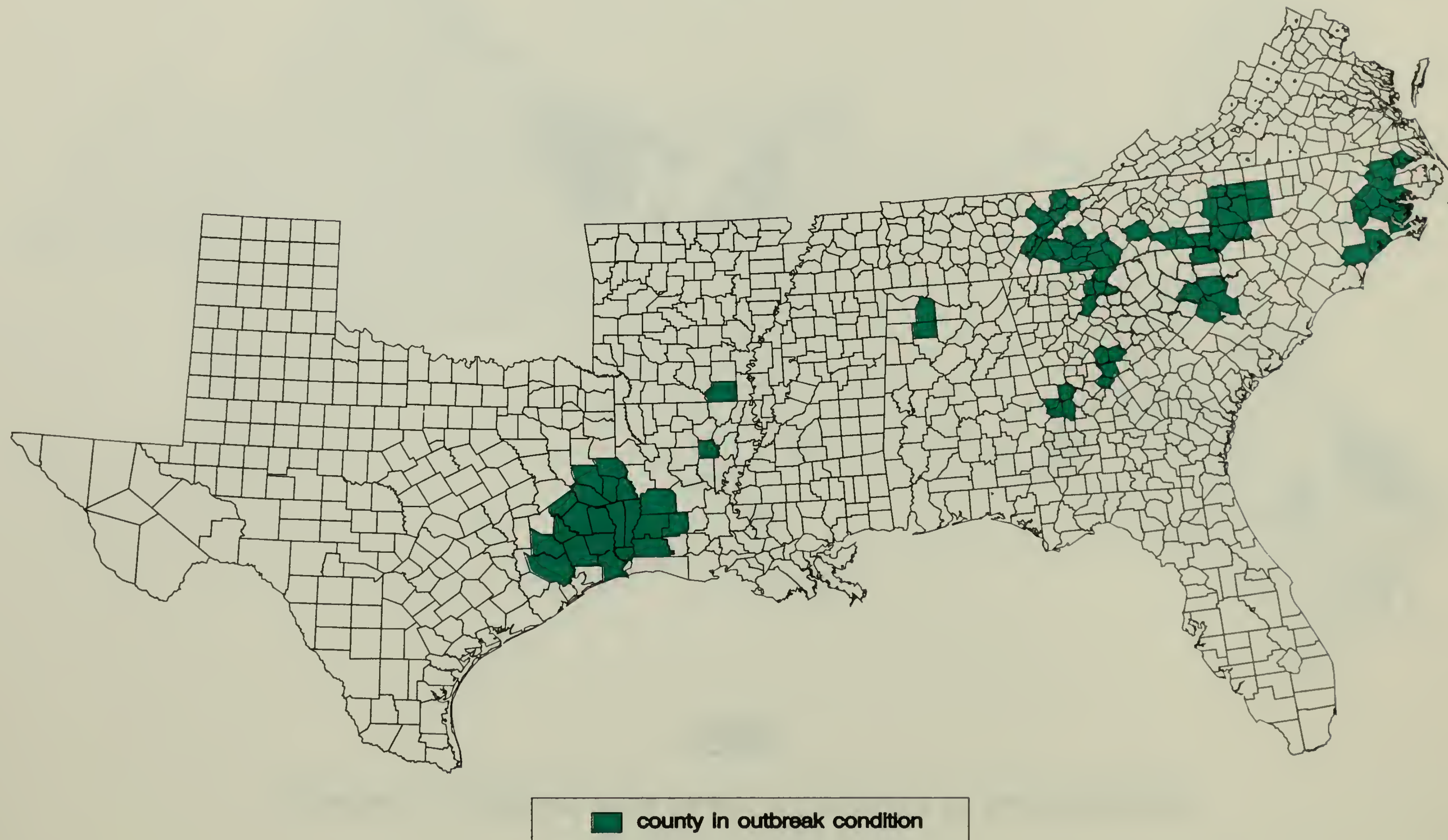


Figure 11

Location of southern pine beetle infestations in the Southeast

1970

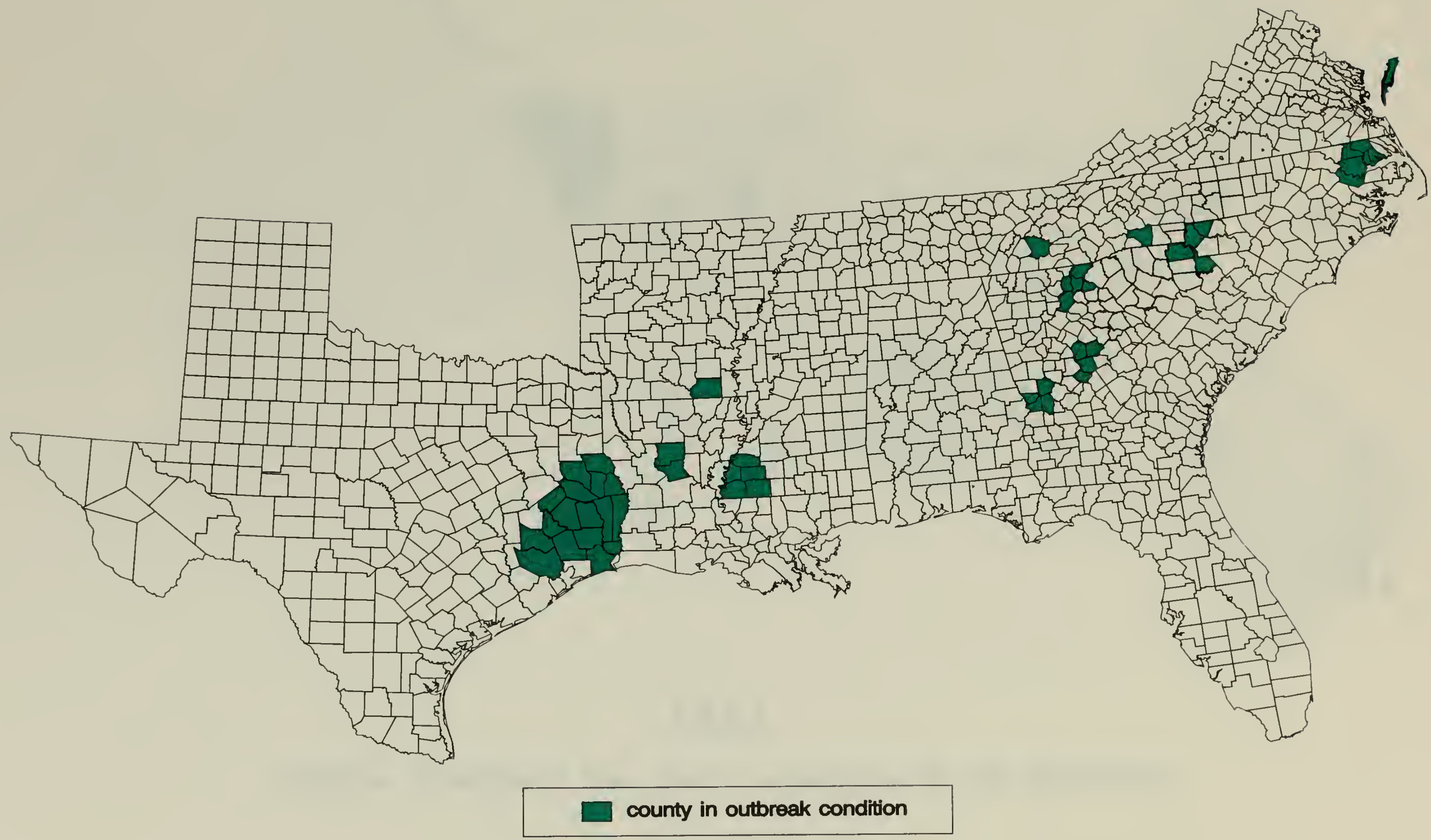


Figure 12

Location of southern pine beetle infestations in the Southeast

1971

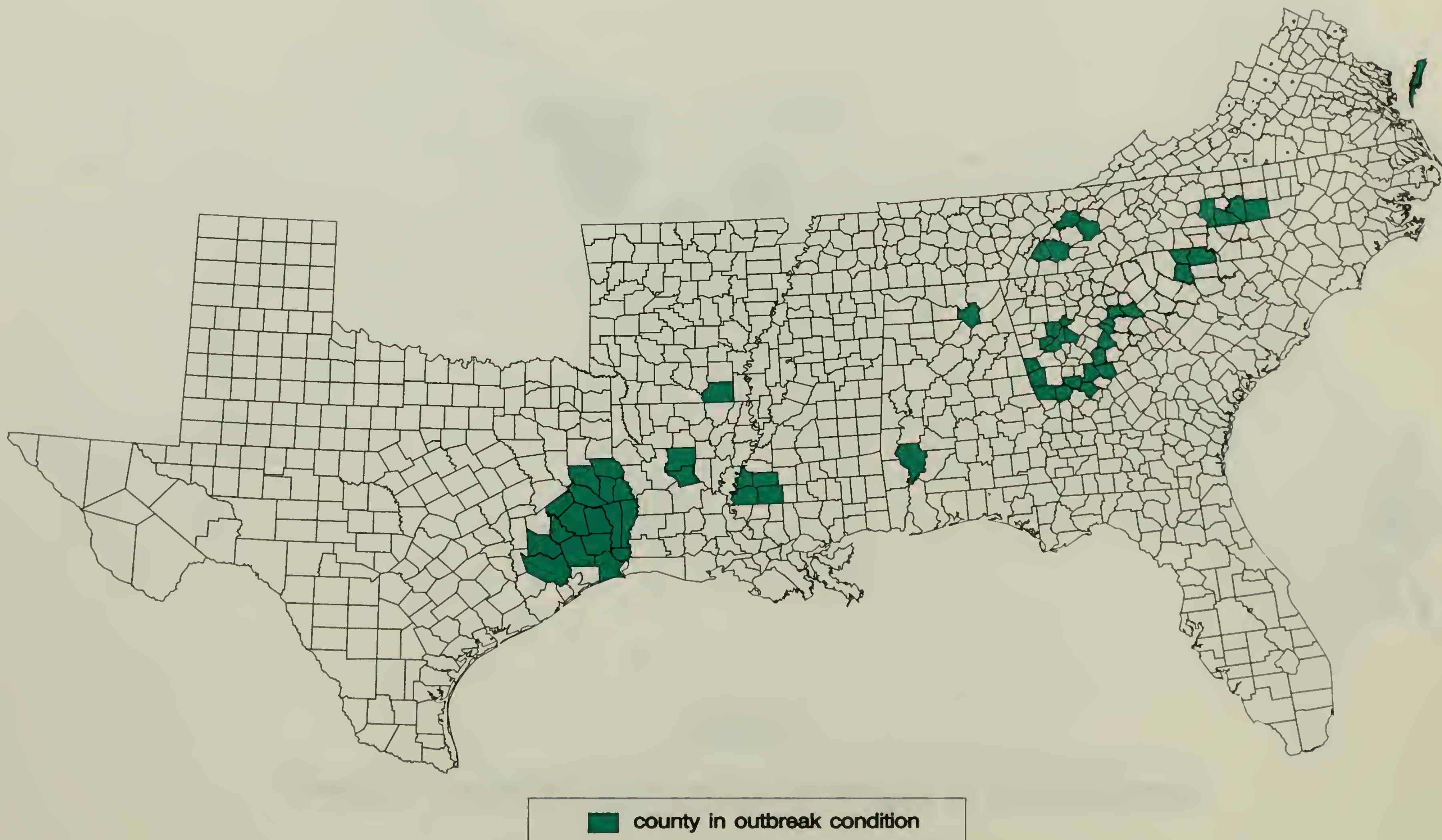


Figure 13

Location of southern pine beetle infestations in the Southeast

1972

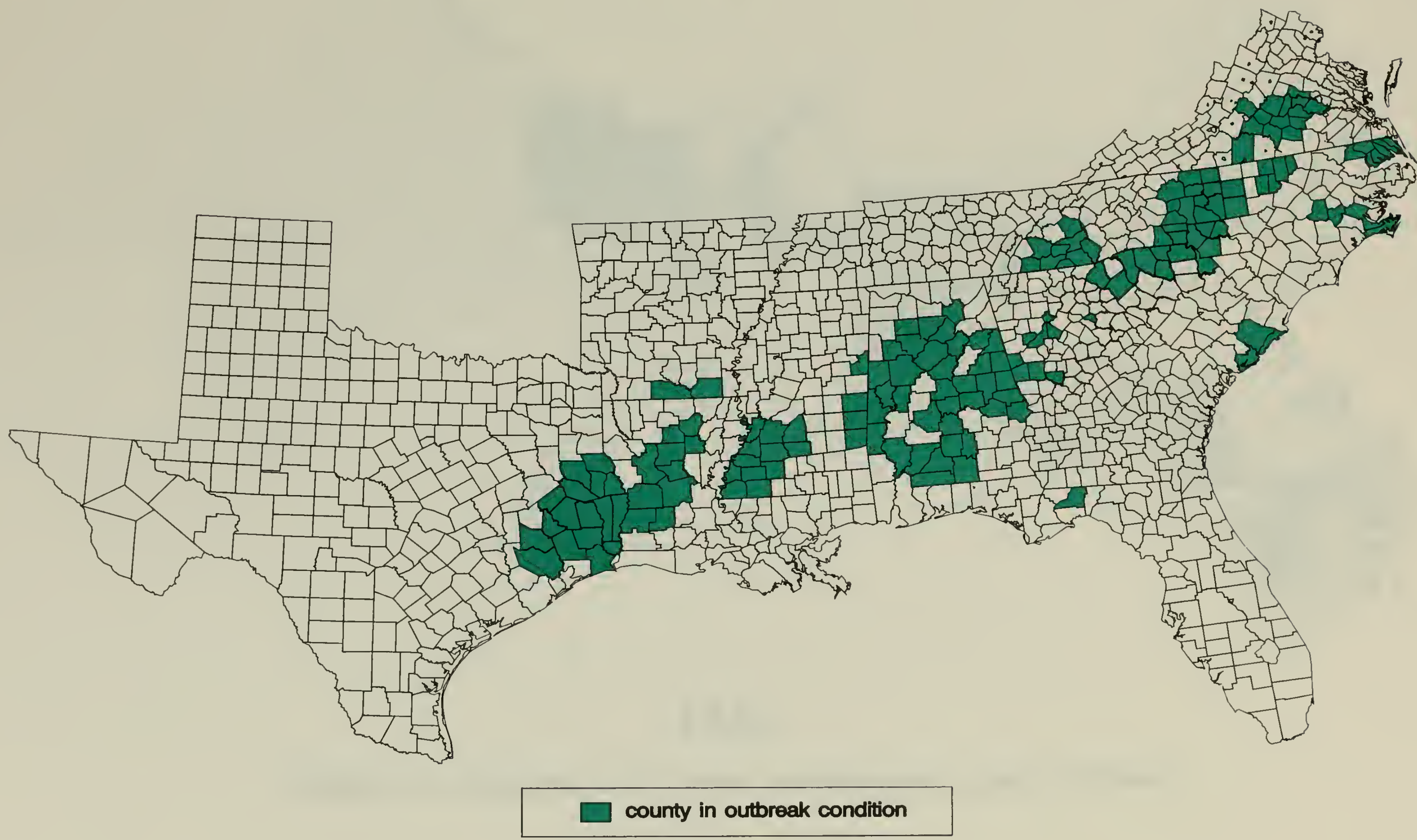


Figure 14

Location of southern pine beetle infestations in the Southeast

1973

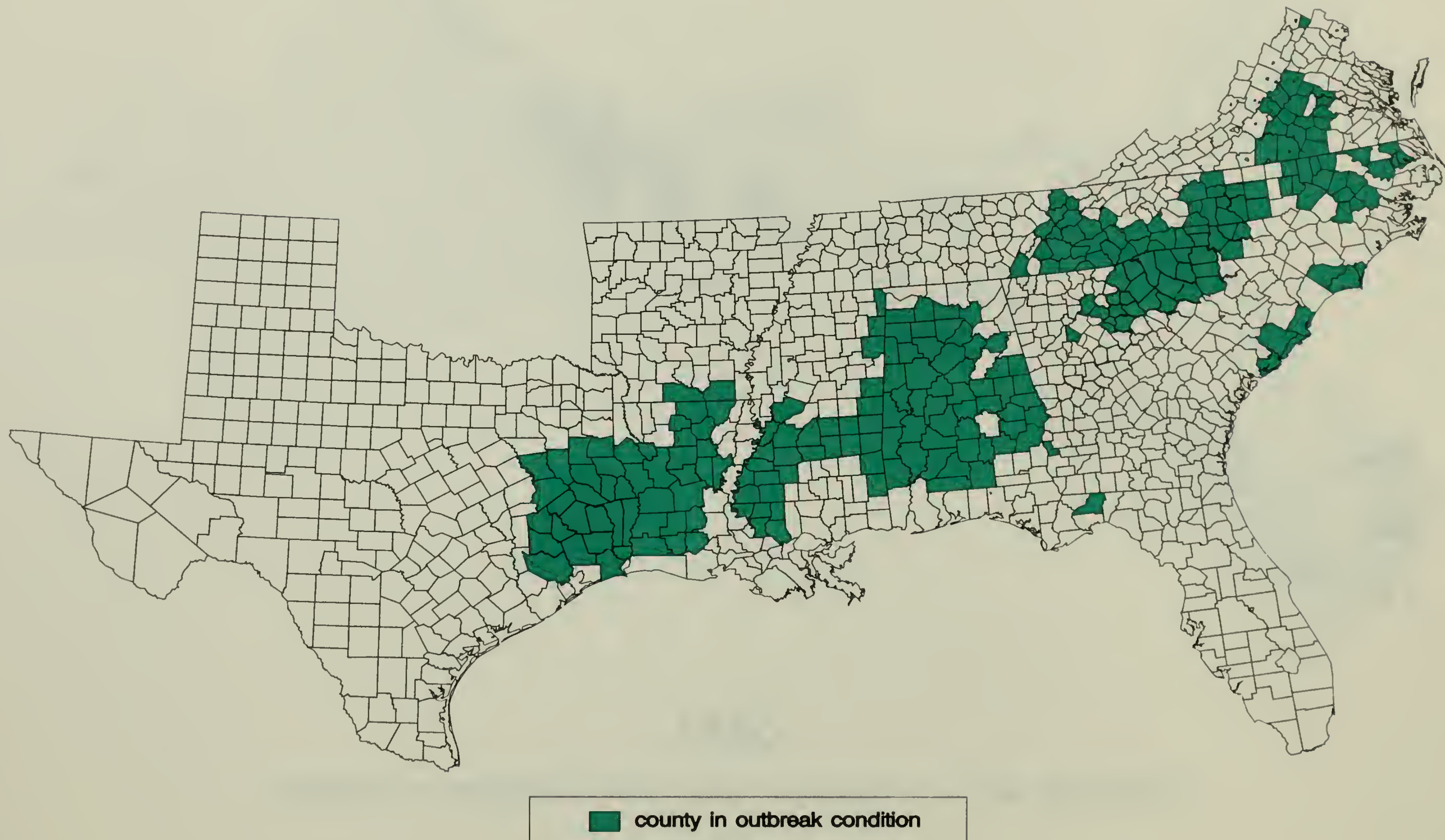


Figure 15

Location of southern pine beetle infestations in the Southeast

1974

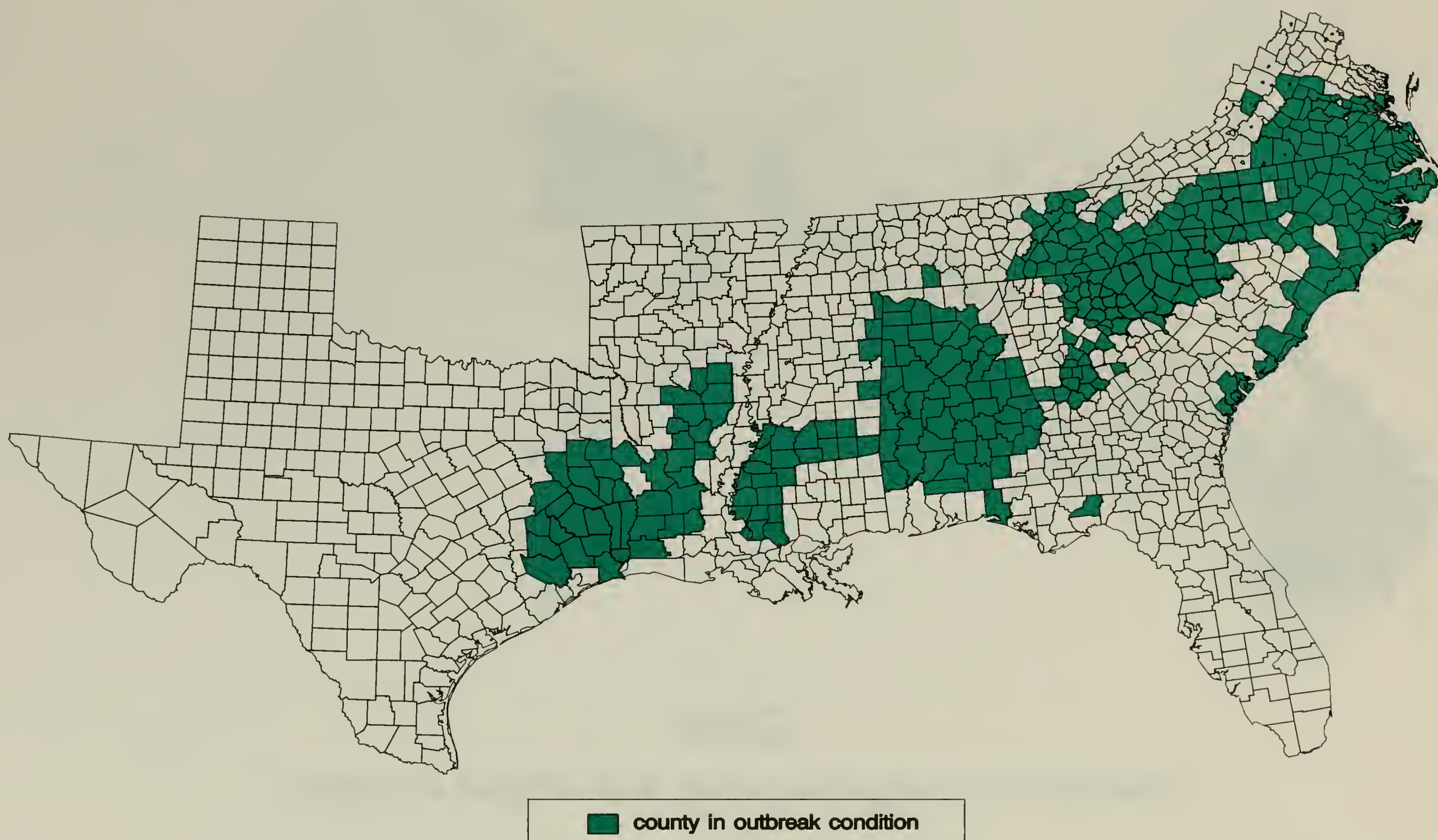


Figure 16

Location of southern pine beetle infestations in the Southeast

1975

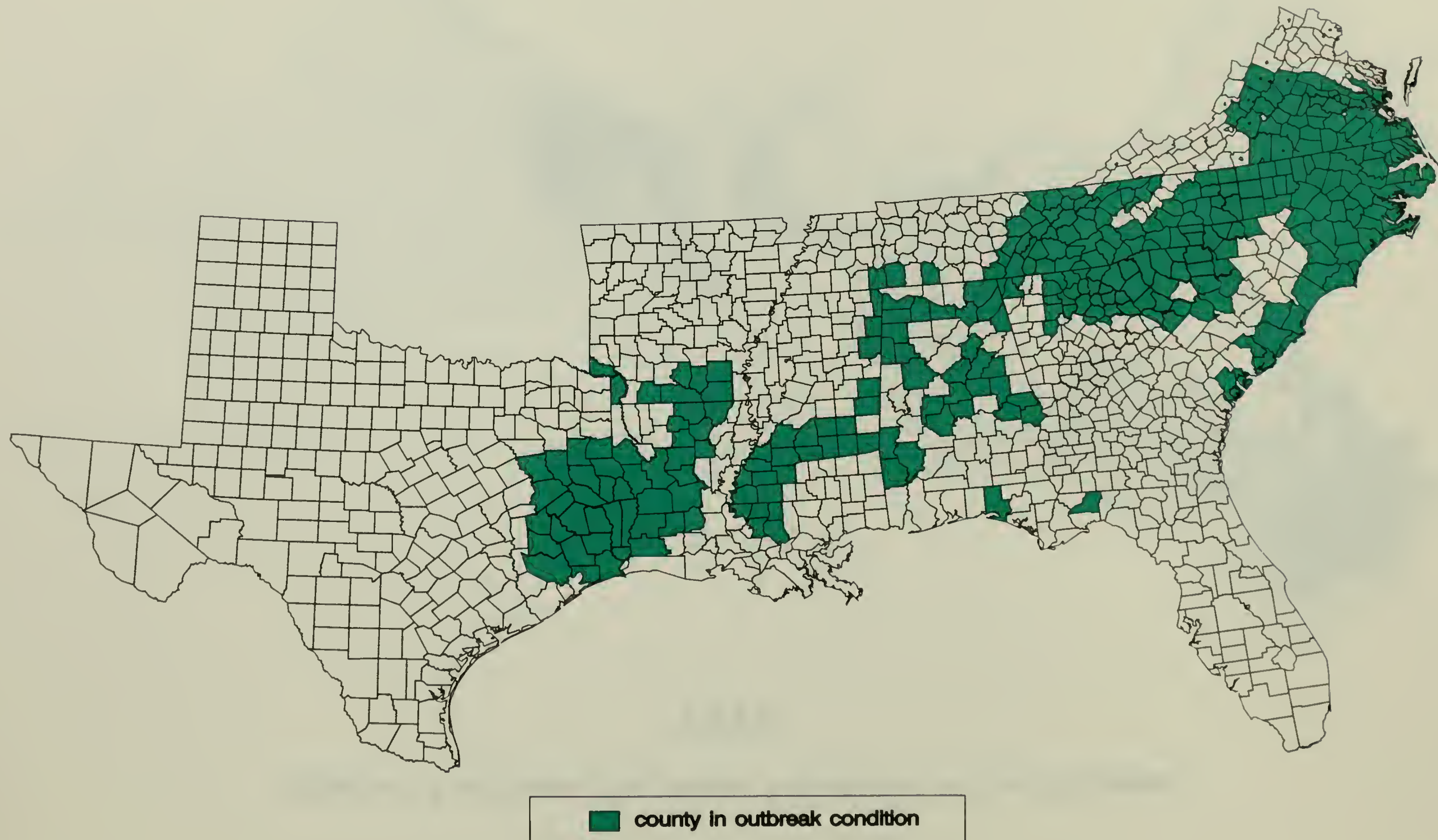


Figure 17

Location of southern pine beetle infestations in the Southeast

1976

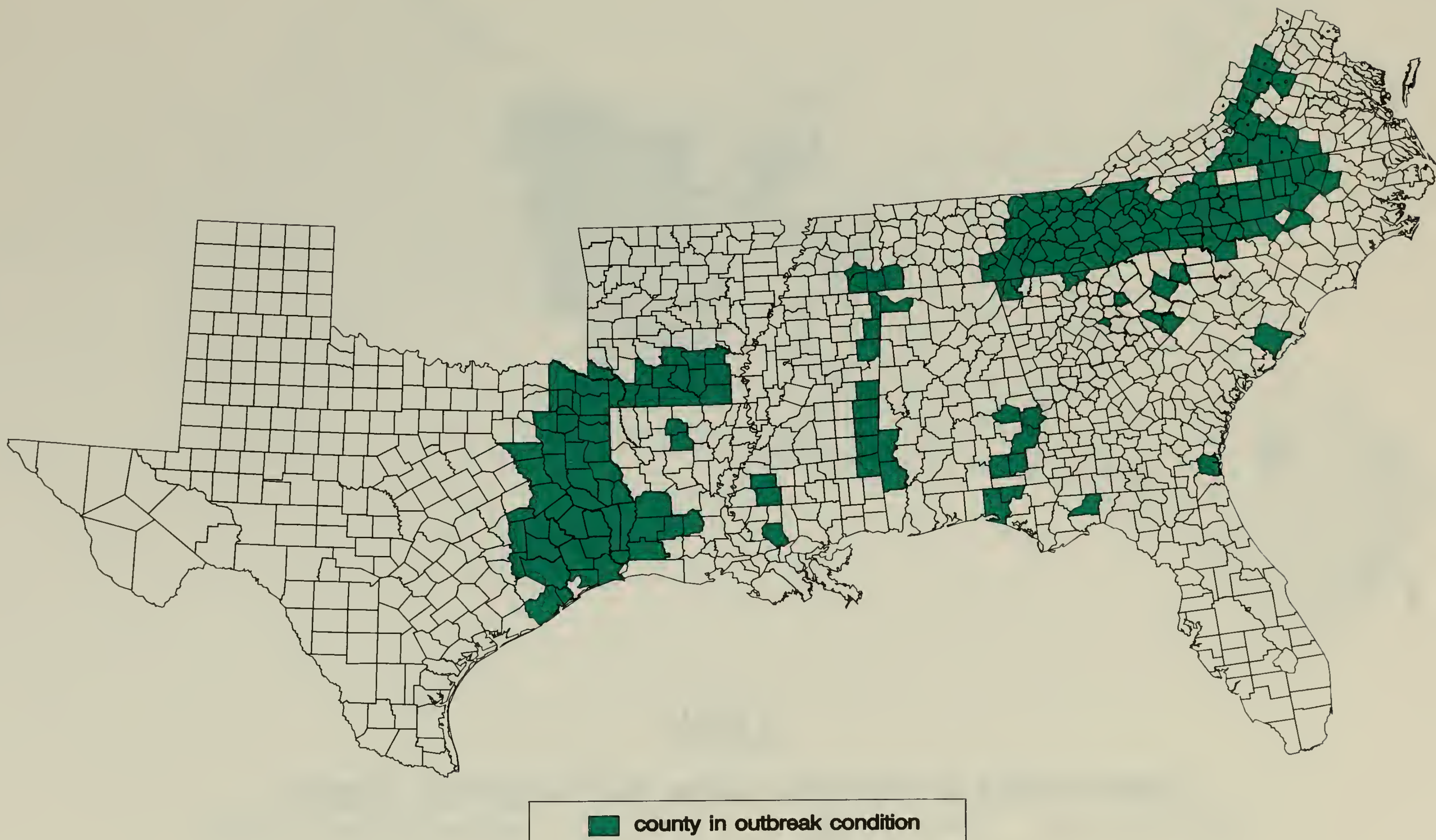


Figure 18

Location of southern pine beetle infestations in the Southeast

1977

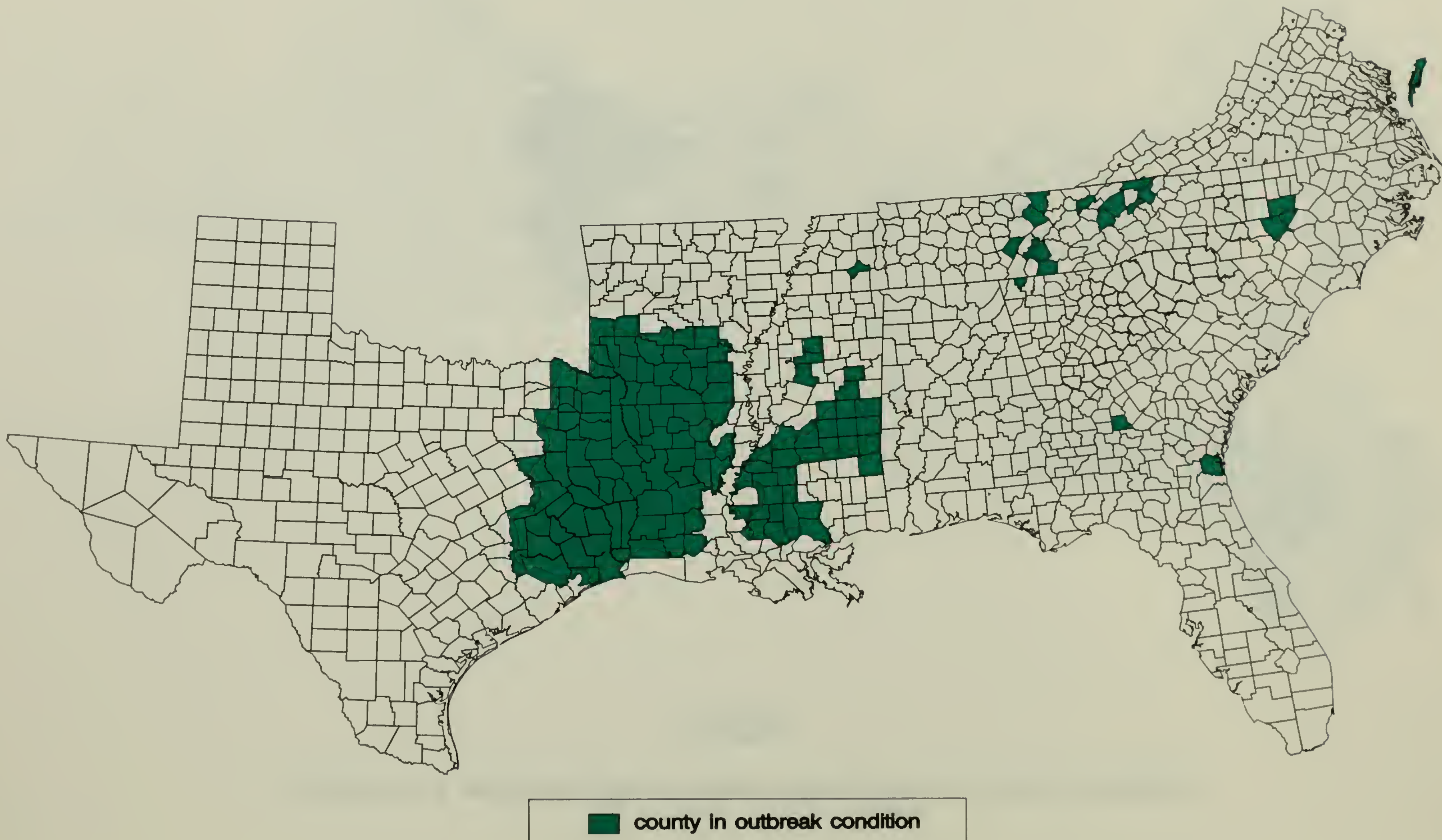


Figure 19

Location of southern pine beetle infestations in the Southeast

1978

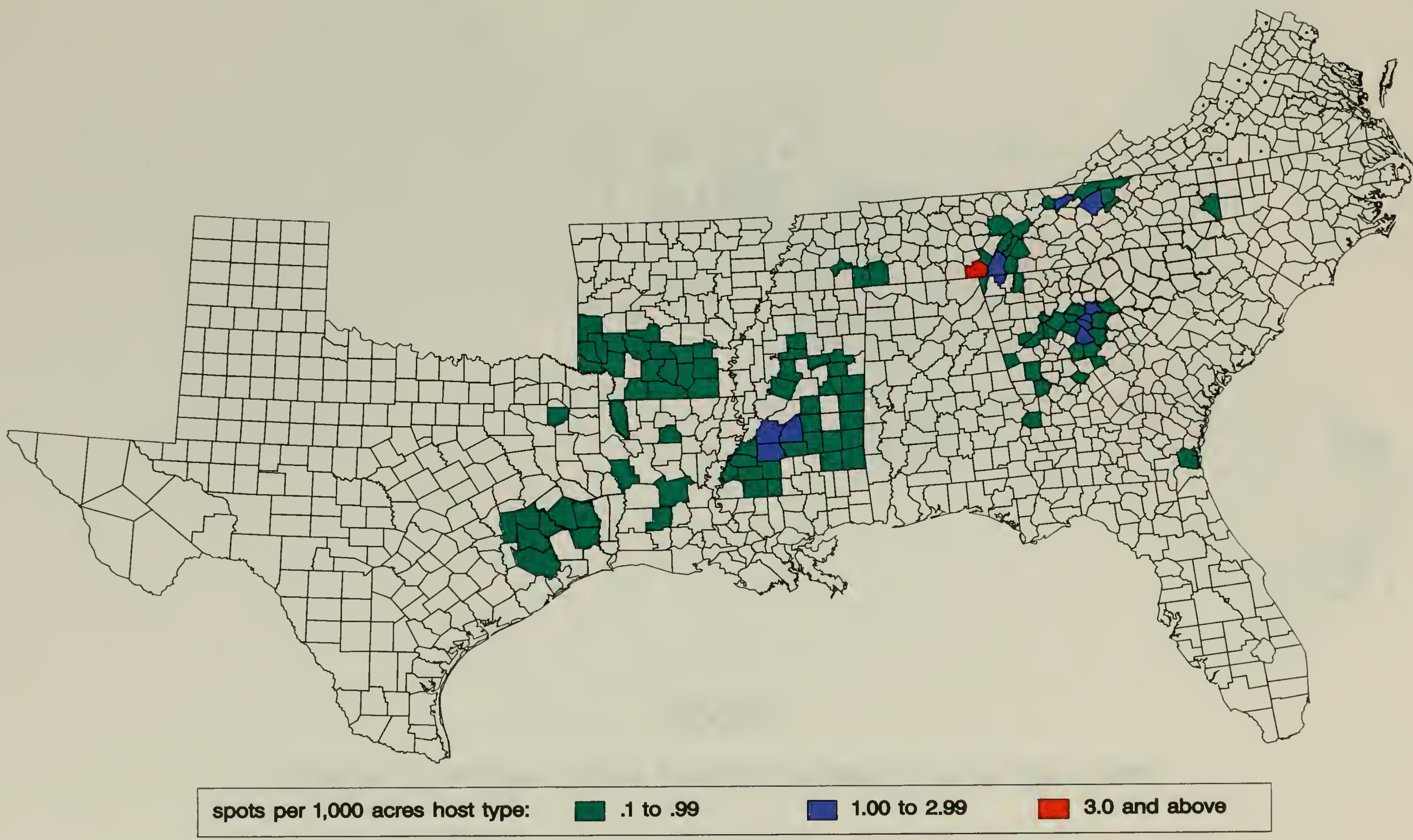


Figure 20

Location of southern pine beetle infestations in the Southeast

1979

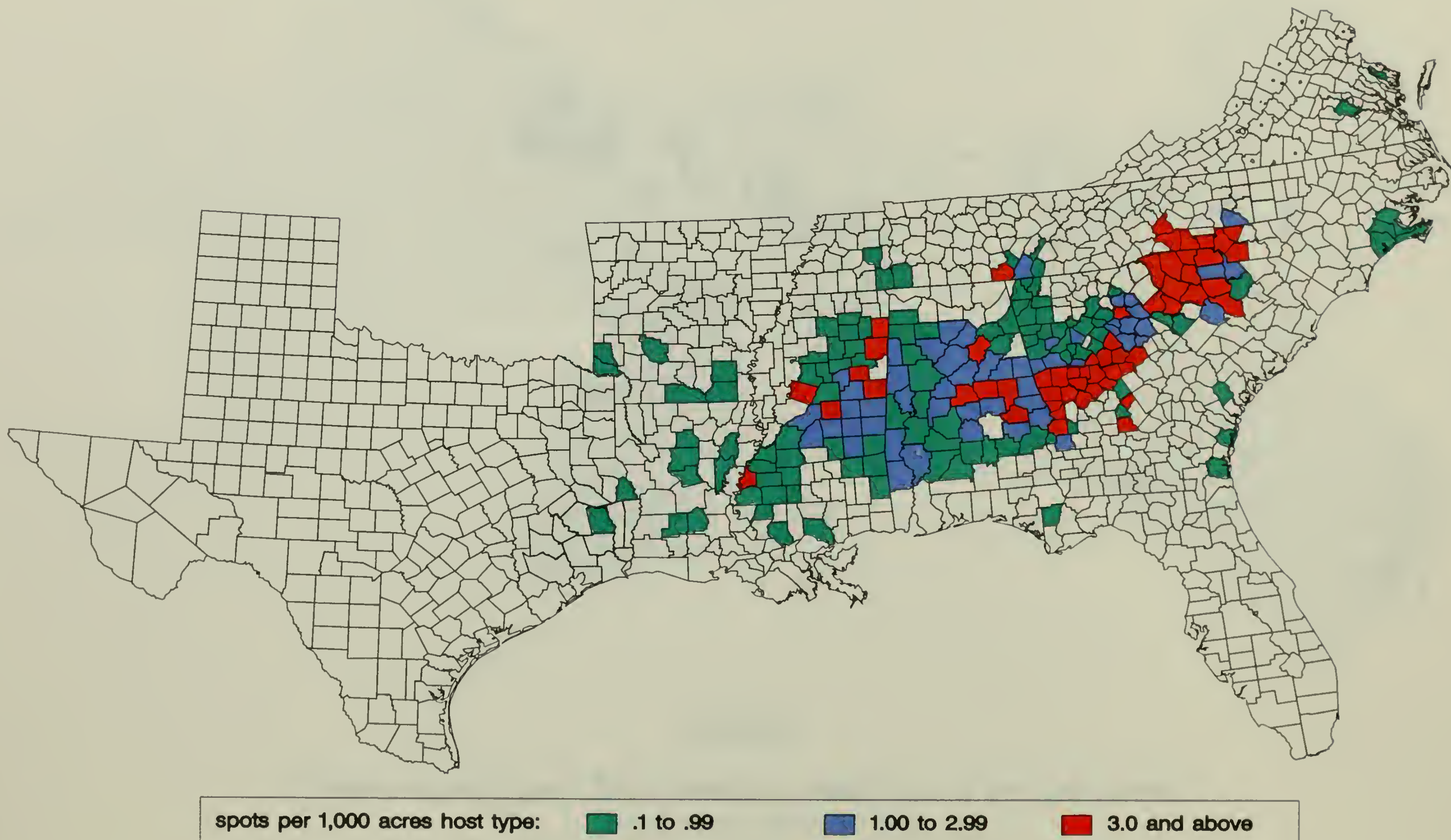
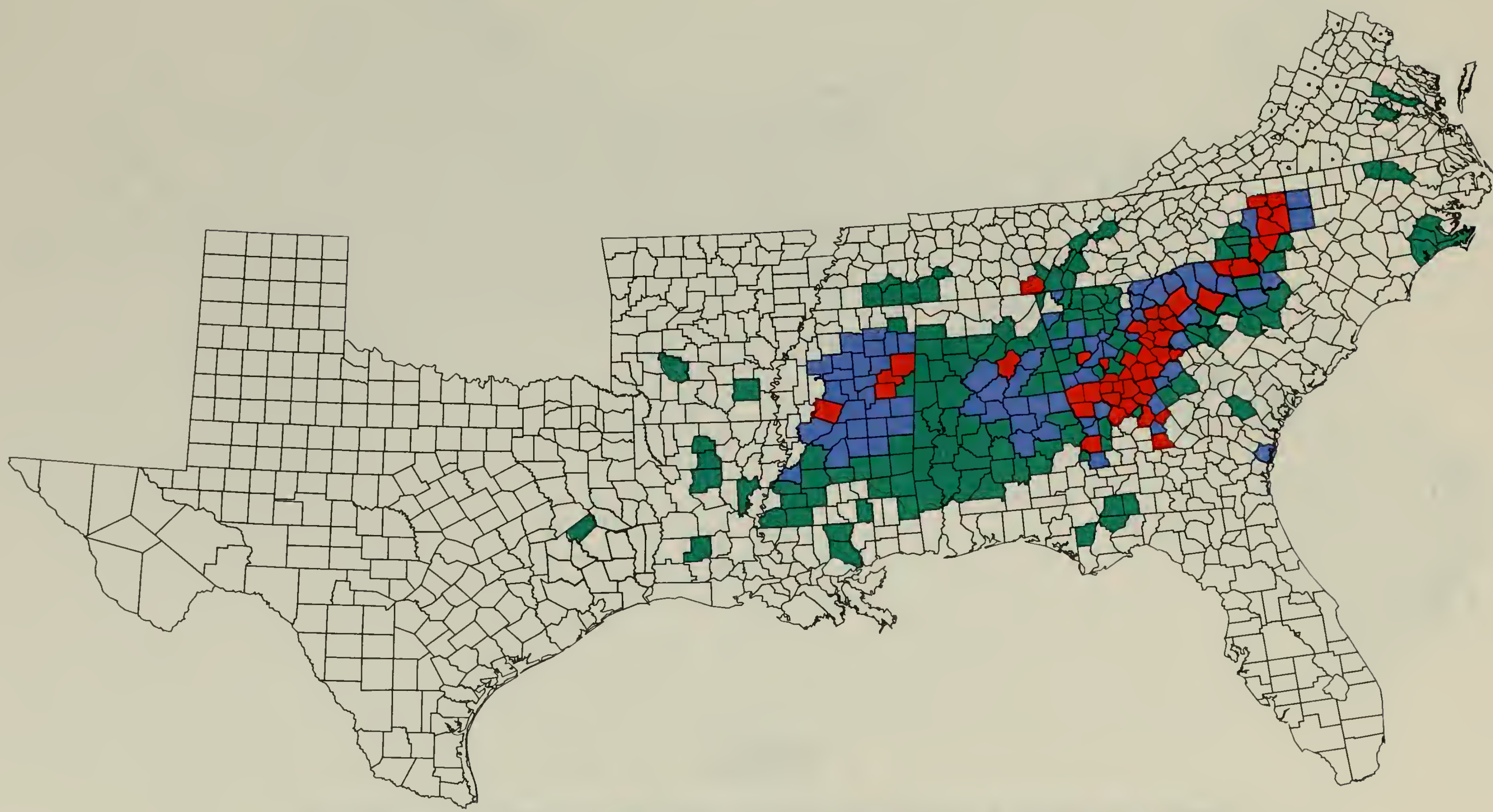


Figure 21

Location of southern pine beetle infestations in the Southeast

1980



spots per 1,000 acres host type: .1 to .99 | 1.00 to 2.99 | 3.0 and above

Figure 22

Location of southern pine beetle infestations in the Southeast

1981

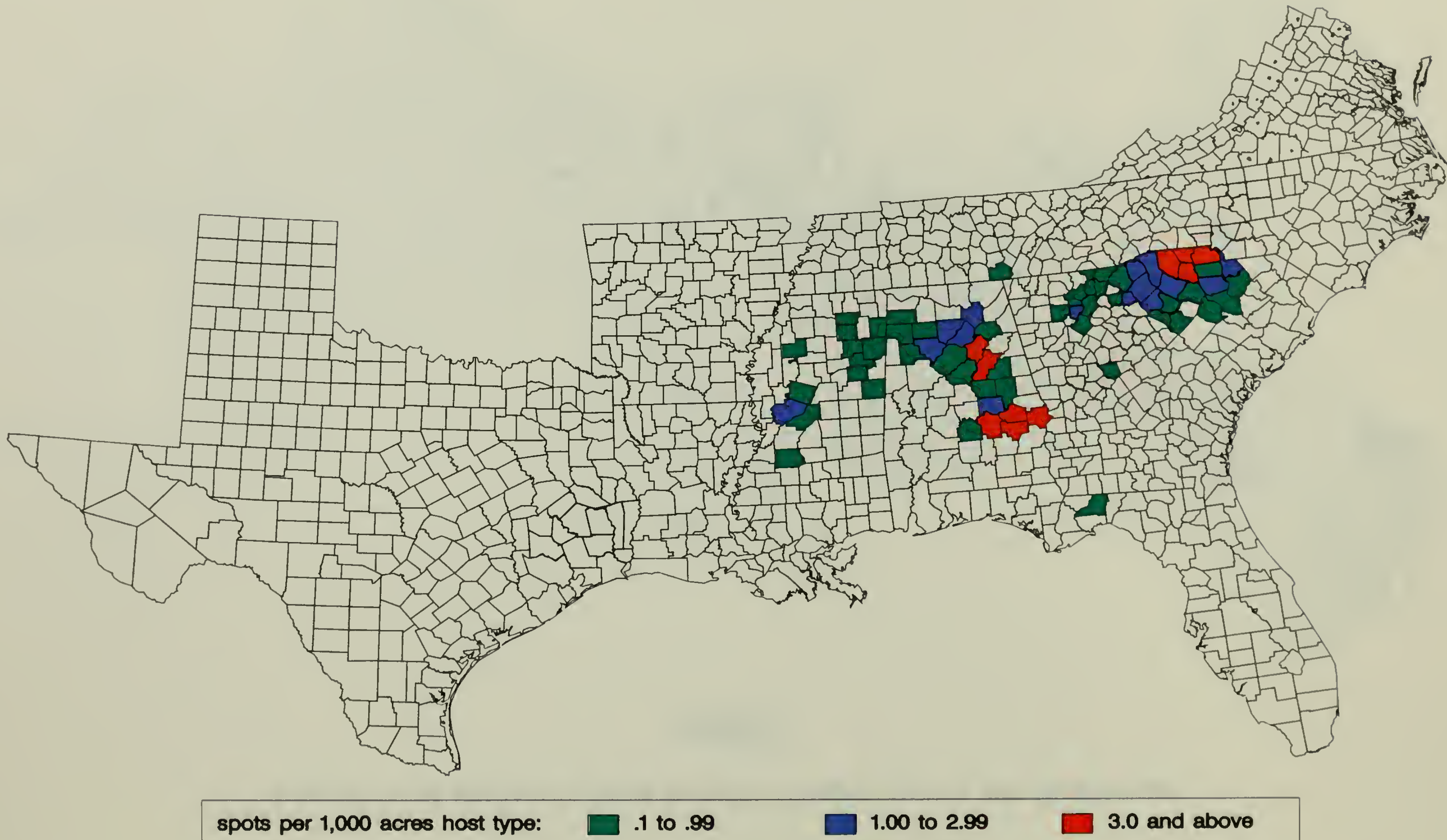


Figure 23

Location of southern pine beetle infestations in the Southeast

1982

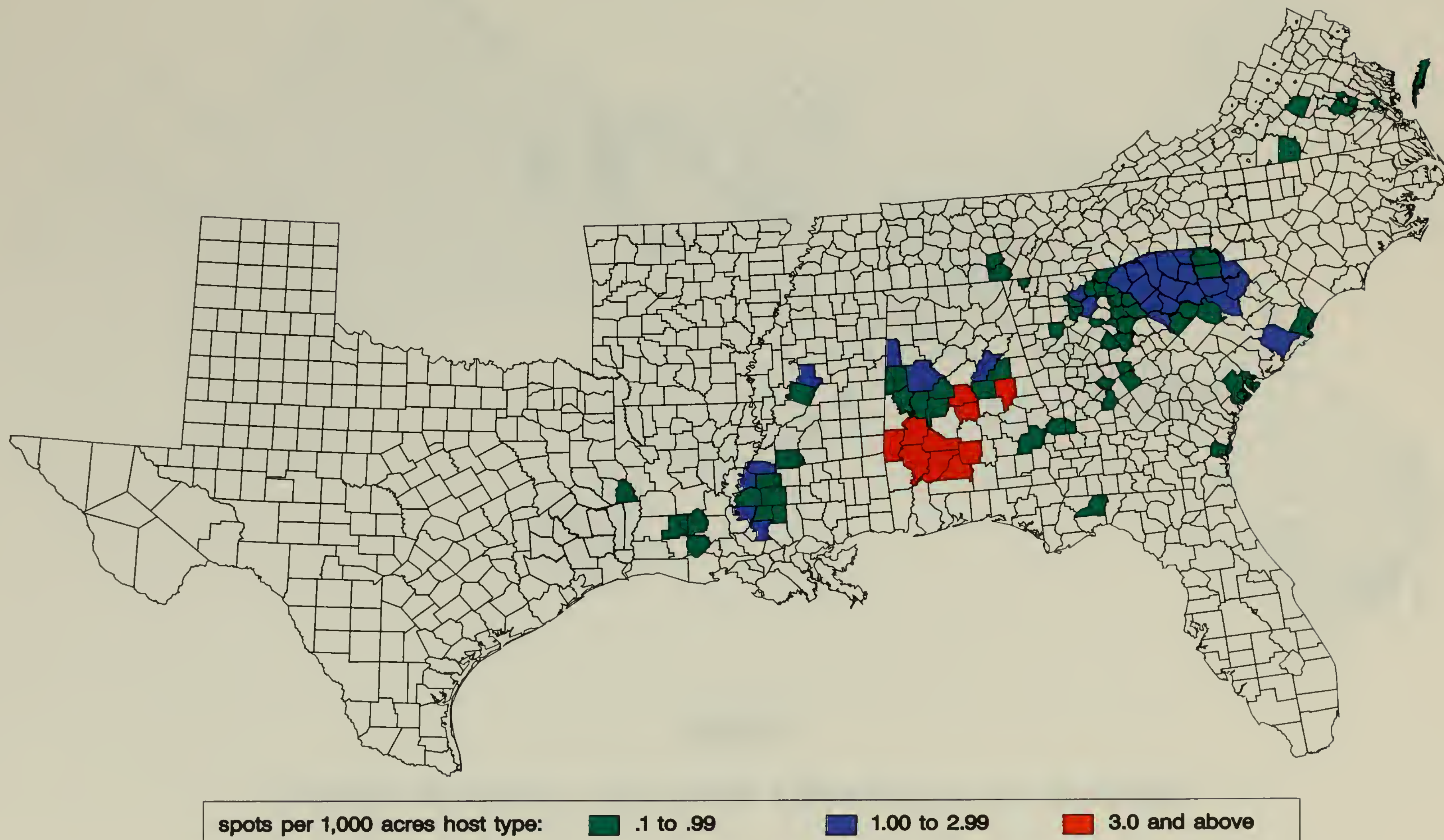


Figure 24

Location of southern pine beetle infestations in the Southeast

1983

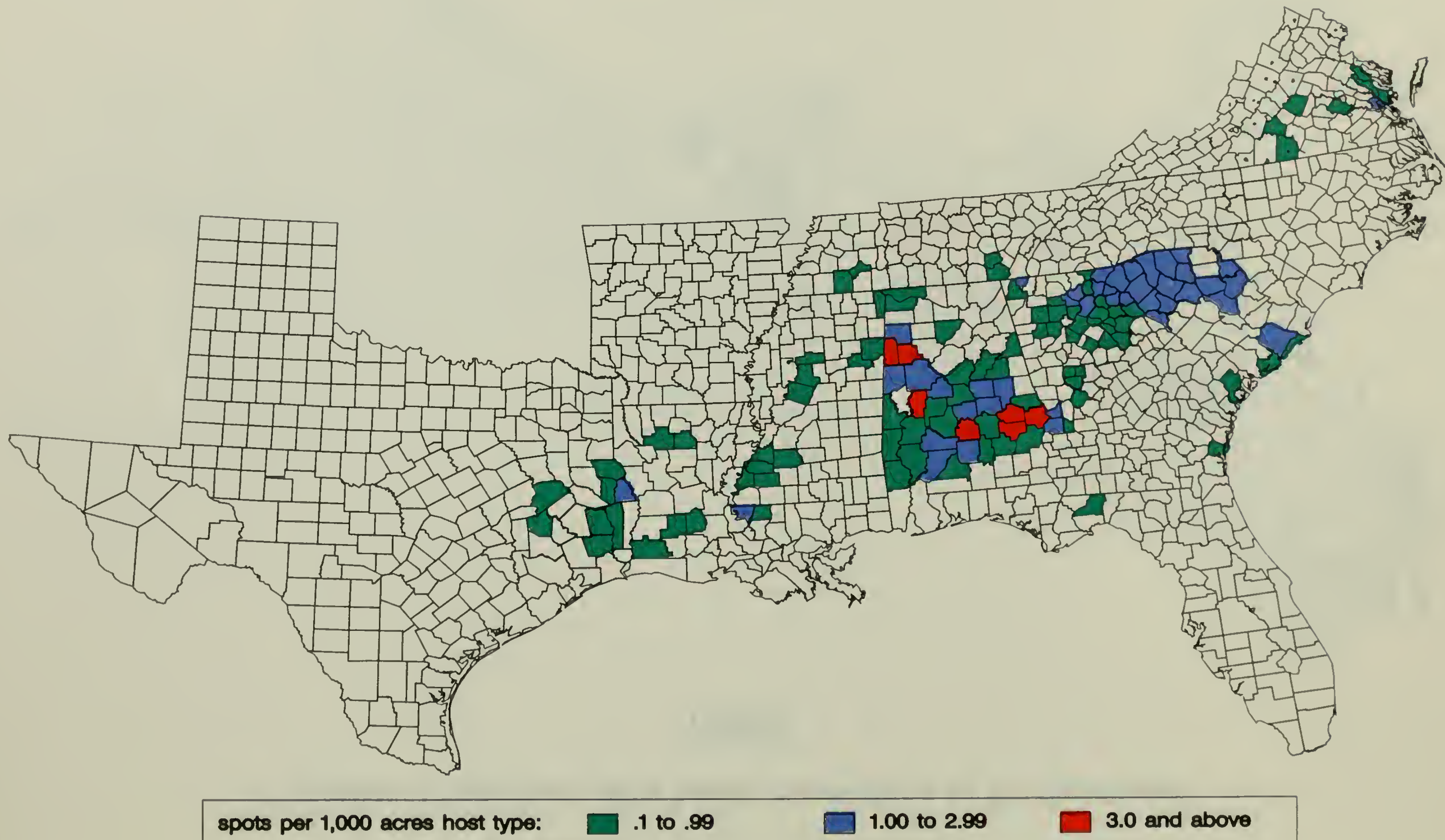


Figure 25

Location of southern pine beetle infestations in the Southeast

1984

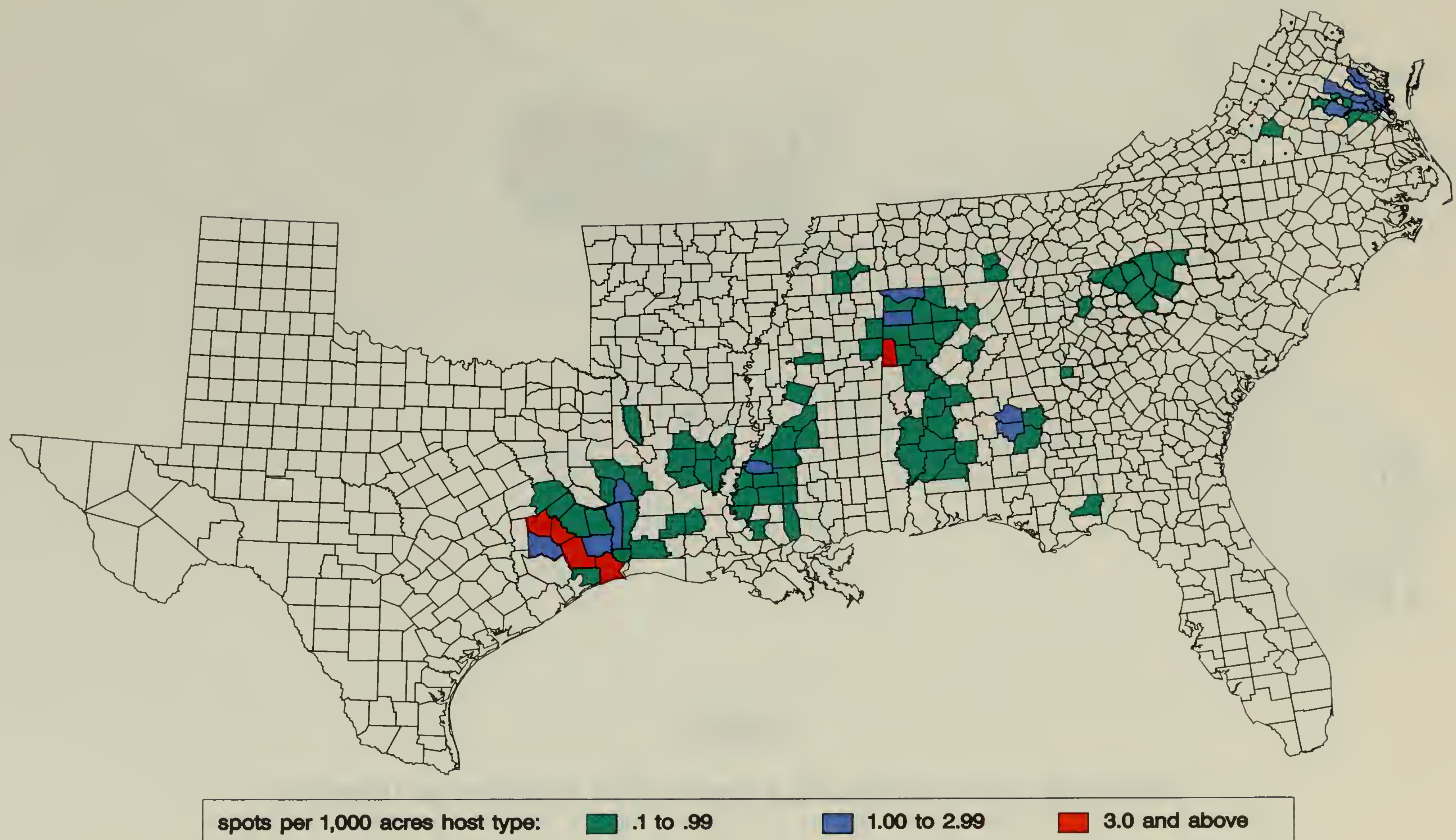
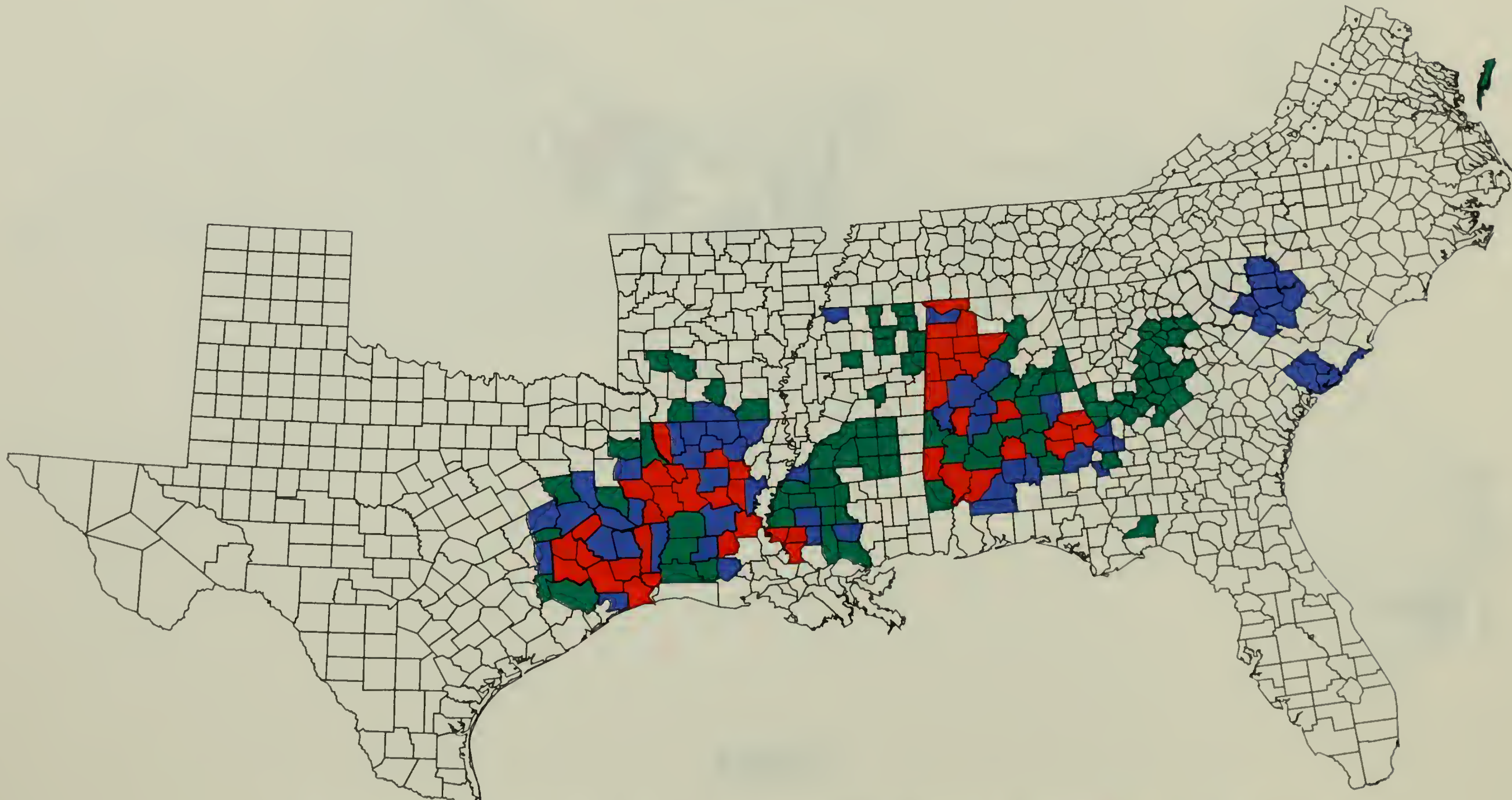


Figure 26

Location of southern pine beetle infestations in the Southeast

1985



spots per 1,000 acres host type: .1 to .99 | 1.00 to 2.99 | 3.0 and above

Figure 27

Location of southern pine beetle infestations in the Southeast

1986

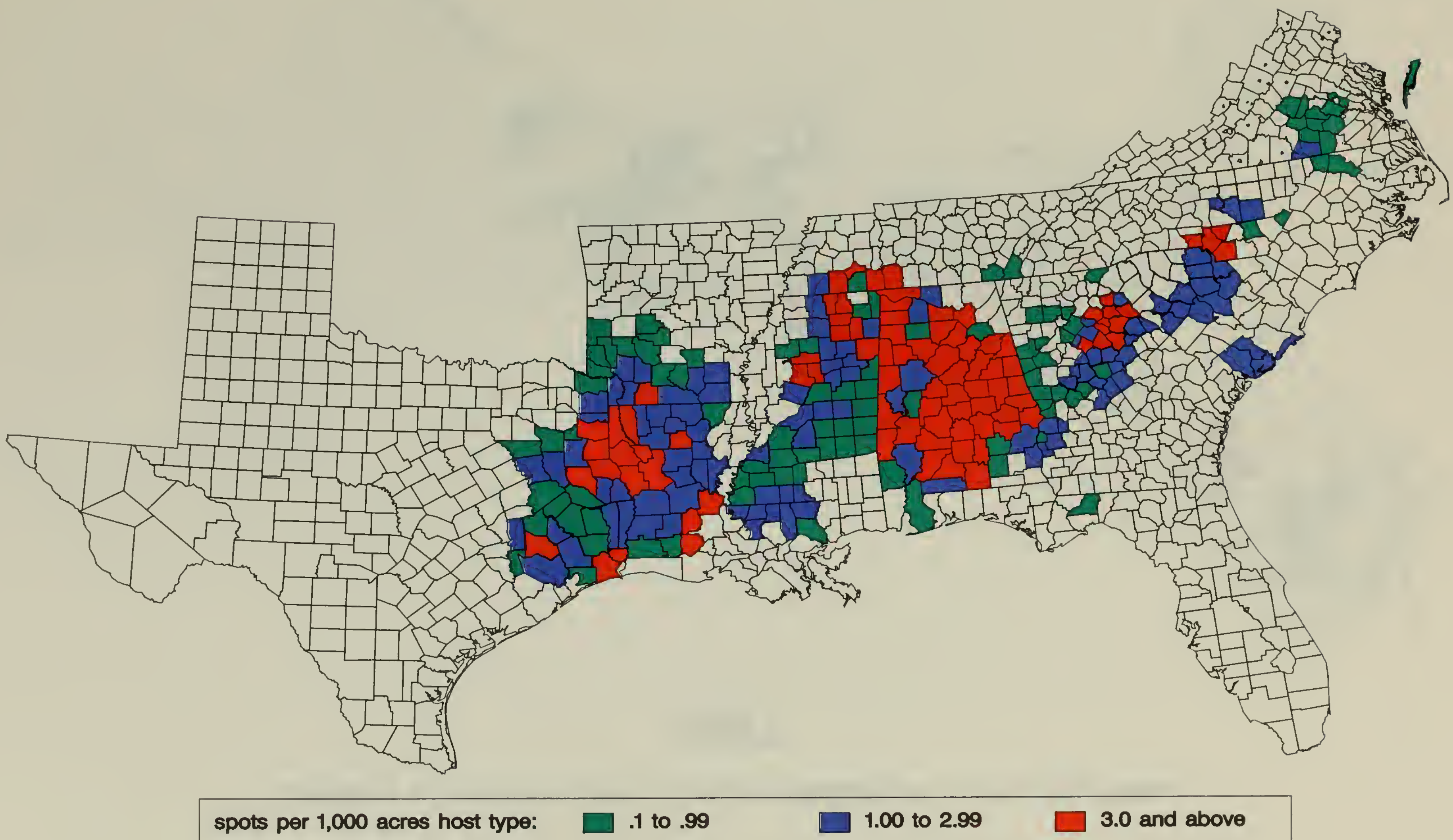


Figure 28

Location of southern pine beetle infestations in the Southeast

1987

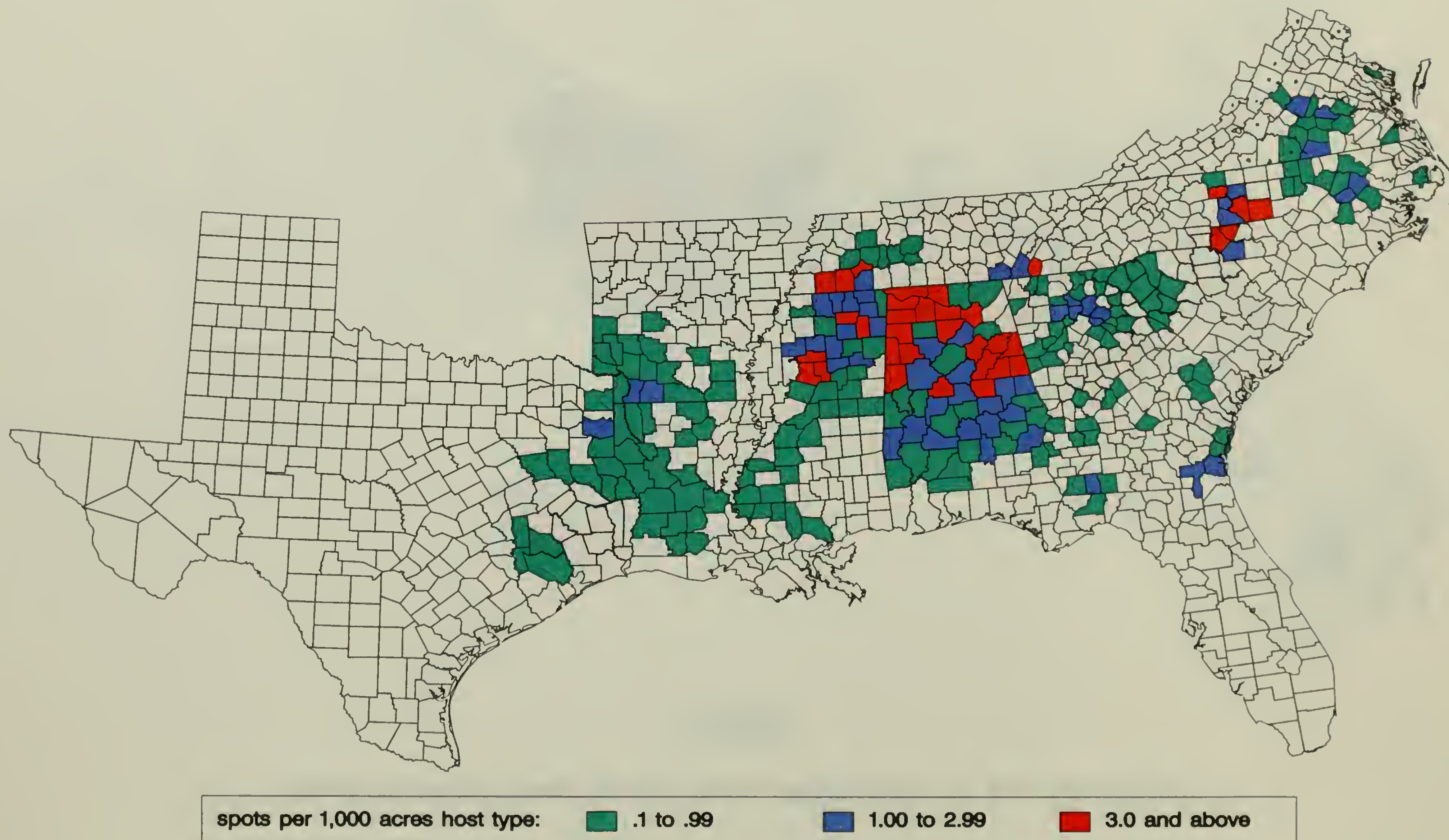


Figure 29

Location of southern pine beetle infestations in the Southeast

1988

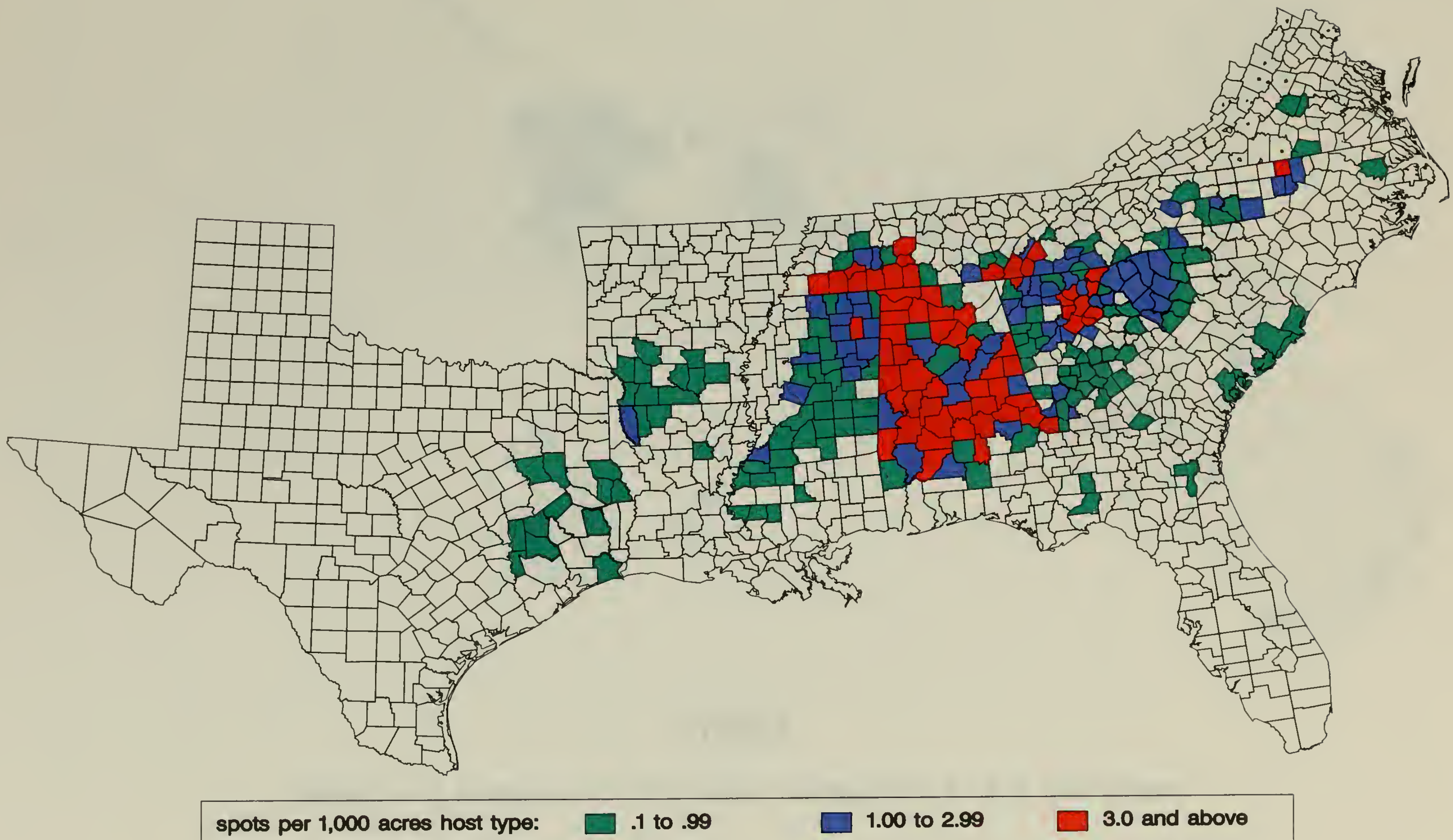
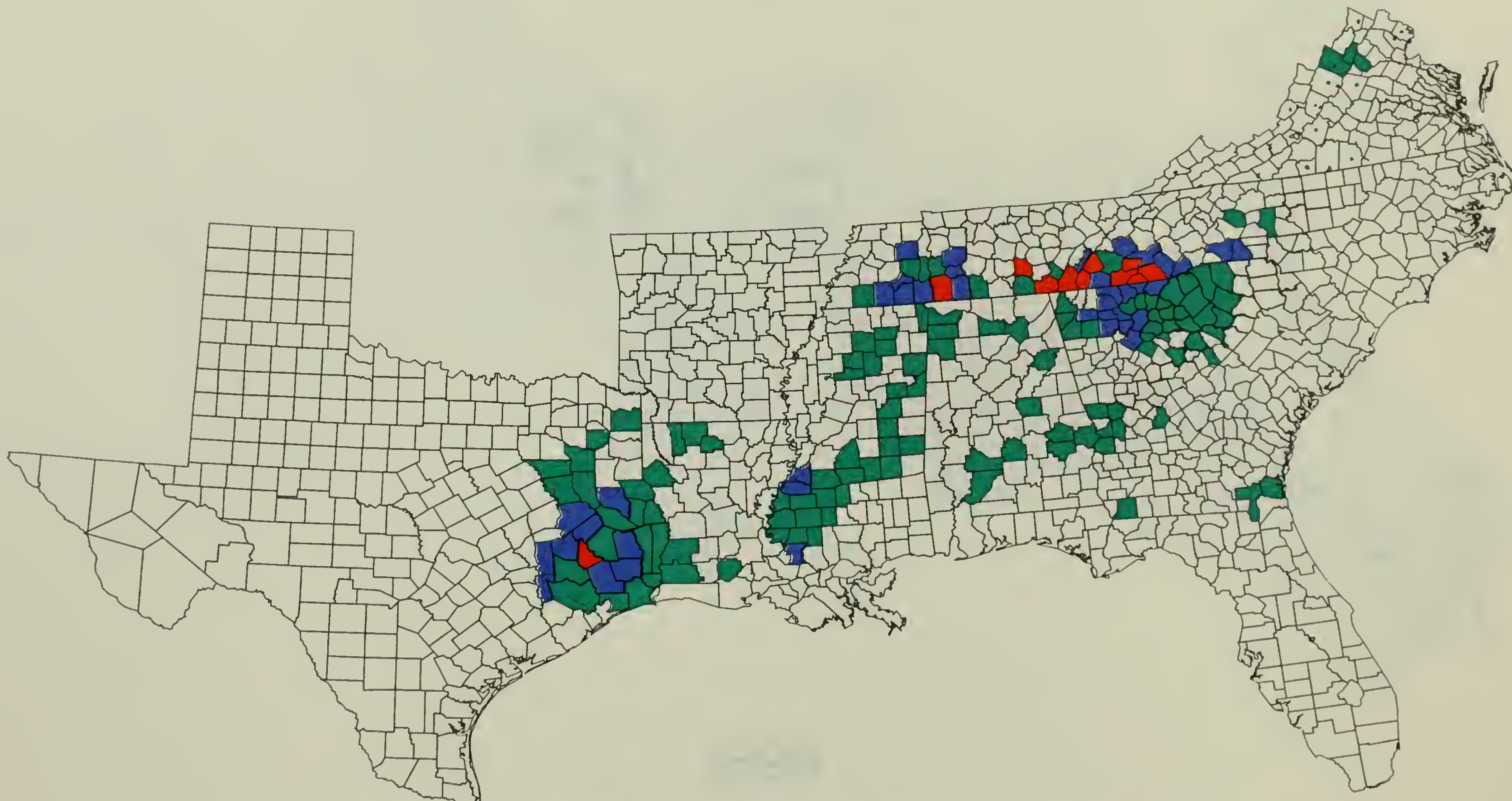


Figure 30

Location of southern pine beetle infestations in the Southeast

1989

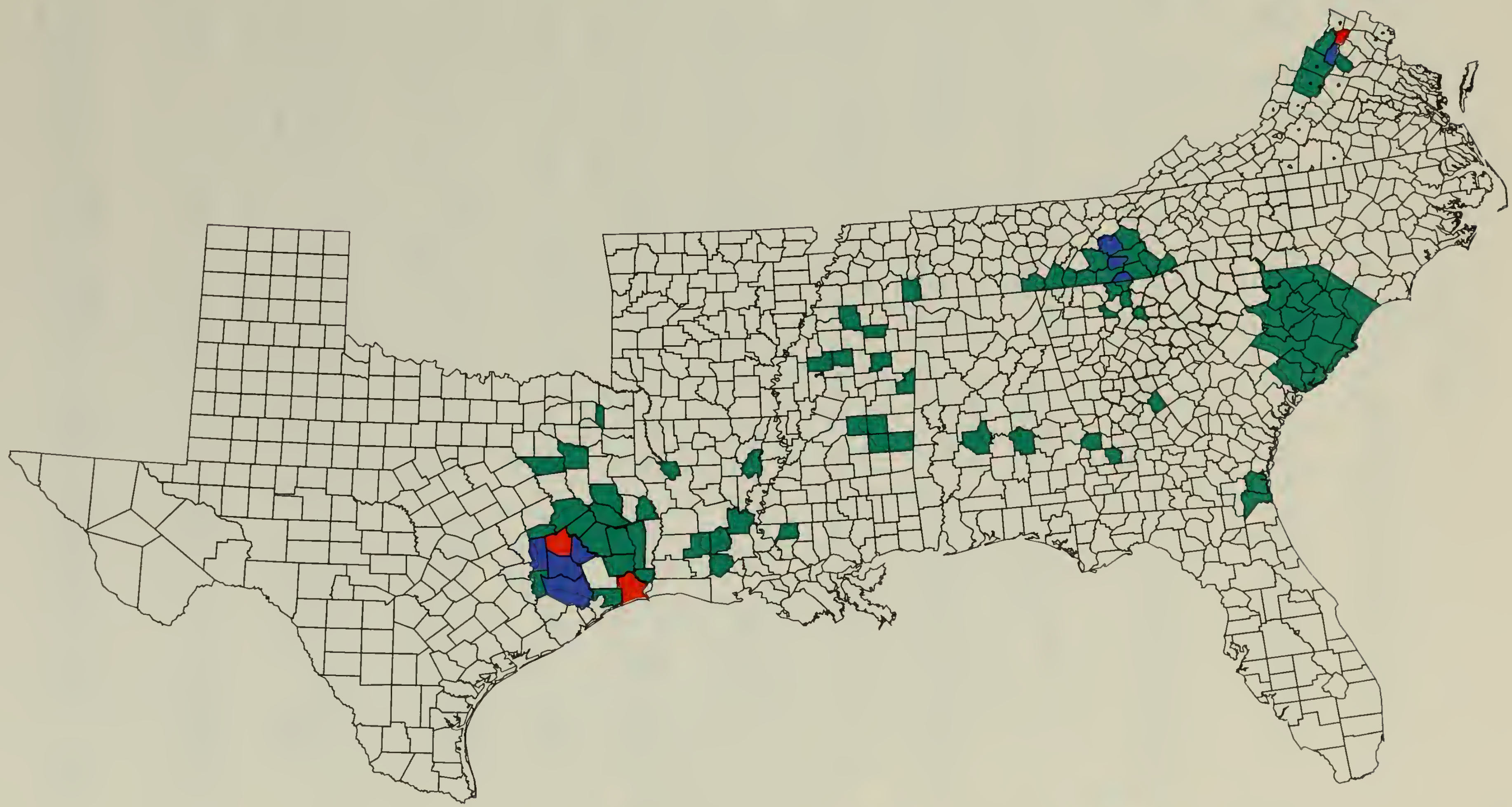


spots per 1,000 acres host type: .1 to .99 | 1.00 to 2.99 | 3.0 and above

Figure 31

Location of southern pine beetle infestations in the Southeast

1990



spots per 1,000 acres host type: .1 to .99 | 1.00 to 2.99 | 3.0 and above

REFERENCES

Anon. 1933. Report of studies conducted at Asheville, NC. USDA, Bureau of Entomology and Plant Quarantine, Forest Insect Investigations, 31 pp.

Anon. 1950. Southern Forest Experiment Station Quarterly Report (Oct.-Dec.).

Beal, J. A. 1929. Tree injection.

Beal, James A. and Calvin L. Massey. 1945. Bark beetles and ambrosia beetles (Coleoptera: Scolytoidea). Duke University School of Forestry Bulletin 10.

Billings, R. F. 1979. Detecting and aerially evaluating southern pine outbreaks. South. J. Appl. For. 3:50-54.

Bennett, W. H. 1971. Silvicultural techniques will help control bark beetles. Proceedings, 1971 Southern Regional Technical Conference. Society of American Foresters, pp. 289-295.

Billings, Ronald F. 1990. Insect behavioral chemicals: promising new approaches for forest pest management. Forest Farmer 49(3): 13-15.

Billings, R. F. 1979. Detecting and aerially evaluating southern pine beetle outbreaks - operational guides. South. J. Applied Forestry 3: 50-54.

Billings, R. F. and B. G. Hynum. 1980. Southern pine beetle: guide for predicting timber losses from expanding spots in east Texas. Texas For. Ser. Cir. 249. 2 pp.

Billings, Ronald F. 1989. Old friends, old enemies. Texas Forestry 30(10).

Billings, R. F. 1980. Direct control. Chapter 10 in "The southern pine beetle." R. C. Thatcher, J. L. Searcy, J. E. Coster, and G. O. Hertel, eds. USDA Tech. Bull. 1631. pp. 179-192.

Billings, R. F. and H. A. Pase III. 1979. Spot proliferation patterns as a measure of the area-wide effectiveness of southern pine beetle control tactics. In, "Evaluating control tactics for the southern pine beetle." J. E. Coster and J. L. Searcy, eds. USDA Forest Service Tech. Bull. 1613, pp. 86-97.

Billings, R. F. and H. A. Pase, III. 1979a. A field guide for ground checking southern pine beetle spots. USDA Agric. Handbook No. 550. 19 pp.

Billings, R. F. and C. Doggett. 1980. An aerial observer's guide to recognizing and reporting southern pine beetle spots. USDA Agric. Handbook No. 560. 19 pp.

Coulson, R. N., J. L. Foltz, A. M. Mayyasi, F. P. Hain. 1975. Quantitative evaluation of frontalure and cacodylic acid treatment effects on within-tree populations of the southern pine beetle. J. Econ. Entomol. 68: 671-678.

Craighead, F. C. and R. A. St. George. 1938. Experimental work with the introduction of chemicals into the sap stream of trees for control on insects. J. For. 36: 26-34.

Dull, C. W. 1980. Loran-C radio navigation systems as an aid to southern pine beetle surveys. USDA Agricultural Handbook No. 567. Combined Forest Pest Research Development Program, Pineville, LA.

Fries, A. L., L. G. Hamilton, D. L. Rights, and M. J. Smith, eds. 1943. Records of the Moravians in North Carolina. North Carolina Historical Comm., Raleigh. p. 2593.

Gmelin, J. F. 1787. Abhandlung uber bie Wurmtrocknis. Verlay Crusius, Liepzig. Quoted in Southern Forest Research Institute Progress report, July-August 1972.

Hain, F. P. 1980. Sampling and predicting population trends. Pages 107-135 In Thatcher, R. C., J. L. Searcy, J. E. Coster and G. D. Hertel (eds.). The Southern Pine Beetle. USDA Technical Bulletin 1631.

Hastings, Felton L. and Jack E. Coster. 1981. Field and laboratory evaluations of insecticides for southern pine beetle control. USDA Forest Service, SE Forest Experiment Sta. Gen. Tech. Report SE-21, p. 39.

Hopkins, A. D. 1899. Report on investigations to determine the cause of unhealthy conditions of the spruce and pine from 1880-1893. West Virginia Ag. Exp. Sta. Bull. 56, 461 pp.

Hopkins, A. D. 1909. Bark beetles of the Genus Dendroctonus. USDA Bureau of Ent. Bull. 83. 169 pp.

Kinzer, G. W., A. F. Fentiman, T. F. Page, R. L. Folte, J. P. Vite, G. B. Pitman. 1969. Bark beetle attractants: identification, synthesis and field bioassay of a new compound isolated from Dendroctonus. Nature 221: 477-478

Lorio, P. L., Jr. 1980. Rating stands for susceptibility to SPB. Pages 153-163 In Thatcher, R. C., J. L. Searcy, J. E. Coster and G. D. Hertel (eds.). The Southern Pine Beetle. USDA Technical Bulletin 1631.

Mayyasi, A. M., R. N. Coulson, J. L. Foltz and A. E. Harvey. 1975. A quality control approach to the evaluation of survey sampling procedures for the southern pine beetle. Journal of Economic Entomology 68:336-338.

Miles, B. R. 1987. Tragedy of the Four Notch. American Forests 93(3&4): 26-29, 76-78.

Ollieu, M. M. 1969. Evaluation of alternative southern pine beetle control techniques. Texas Forest Service, Pub. 204, 6 pp.

Patterson, J. C. 1930. Control of the mountain pine beetle in lodgepole pine by use of solar heat. USDA Tech. Bull. 198.

Payne, T. L. and R. F. Billings. 1989. Evaluation of (s)-verbenone applications for suppressing southern pine beetle (Coleoptera: Scolytidae) infestations. J. Econ. Entomol. 82: 1702-1708.

Pratt, J. H. 1911. Planning to control the bark beetle. N. C. Geol. and Econ. Survey Pres. Bull. 52, 4 pp.

Pratt, J. H. 1912. The southern pine beetle and its control. N.C. Geol. and Econ. Survey Bull. 4 pp.

Price, T. S. and C. A. Doggett. 1982. A History of Southern Pine Beetle Outbreaks in the Southern United States. The Georgia Forestry Commission, Macon, GA. 35 pp.

Renwick, J. A. 1967. Identification of two oxigenated terpenes from the bark beetles Dendroctonus frontalis and Dendroctonus

Speers, C. F., E. P. Merkel, and B. Ebel. 1955. Tests of insecticides for the control of the southern pine beetle in North Carolina Assoc. South. Ag. Workers Proc. 52:100.
beevicomis . Contrib. Boyce Thompson Instit. 23(10): 355-360.

Stephen, F. M. and M. P. Lih. 1985. A Dendroctonus frontalis infestation growth model: organization, refinement, and utilization, pp. 186-199. In, S. J. Branham and R. C. Thatcher (eds.) Proc. Integrated Pest Management Reserach Symposium. USDA Gen. Tech. Rep. SO-56, Asheville, NC.

St. George, R. H. and R. W. Caird. 1929. Report on tree medication studies. USDA Bureau of Entomology and Plant Quarantine, Forest Insect Investigations. 13 pp.

St. George, R. H. 1932. Progress report of experiments to control the southern pine beetle under shade tree conditions. USDA, Bureau of Entomology and Plant Quarantine, Forest Insect Investigations. 11 pp.

St. George, R. H. and Huckenpahler. 1933. Progress report on tree injection studies. USDA, Bureau of Entomology and Plant Quarantine, Forest Insect Investigations.

St. George, R. H. 1934. Tree injection report. USDA, Bureau of Entomology and Plant Quarantine, Forest Insect Investigations. 19 pp.

Swain, K. M. and M. C. Remion. 1981. Direct control methods for the southern pine beetle. USDA Agric. Handbook No. 575. 15 pp.

Thatcher, R. C., G. N. Mason, G. D. Hertel and J. L. Searcy. 1982. Detecting and controlling southern pine beetle. Sou. Jour. App. For. 6(3): 153-158.

Thatcher, R. C., J. L. Searcy, J. E. Coster, and Gerald D. Hertel. 1980. The southern pine beetle. USDA Forest Service Tech. Bull. 1631, p. 266.

Williamson, D. L. and J. P. Vite. 1971. Impact of insecticidal control on the southern pine beetle population in east Texas. J. Econ. Entomol. 64: 1440-1444.

APPENDIX

Table 2.--Southern Pine Beetle Damage in the Southeast. (Based on sketchy data from 1882-1960)

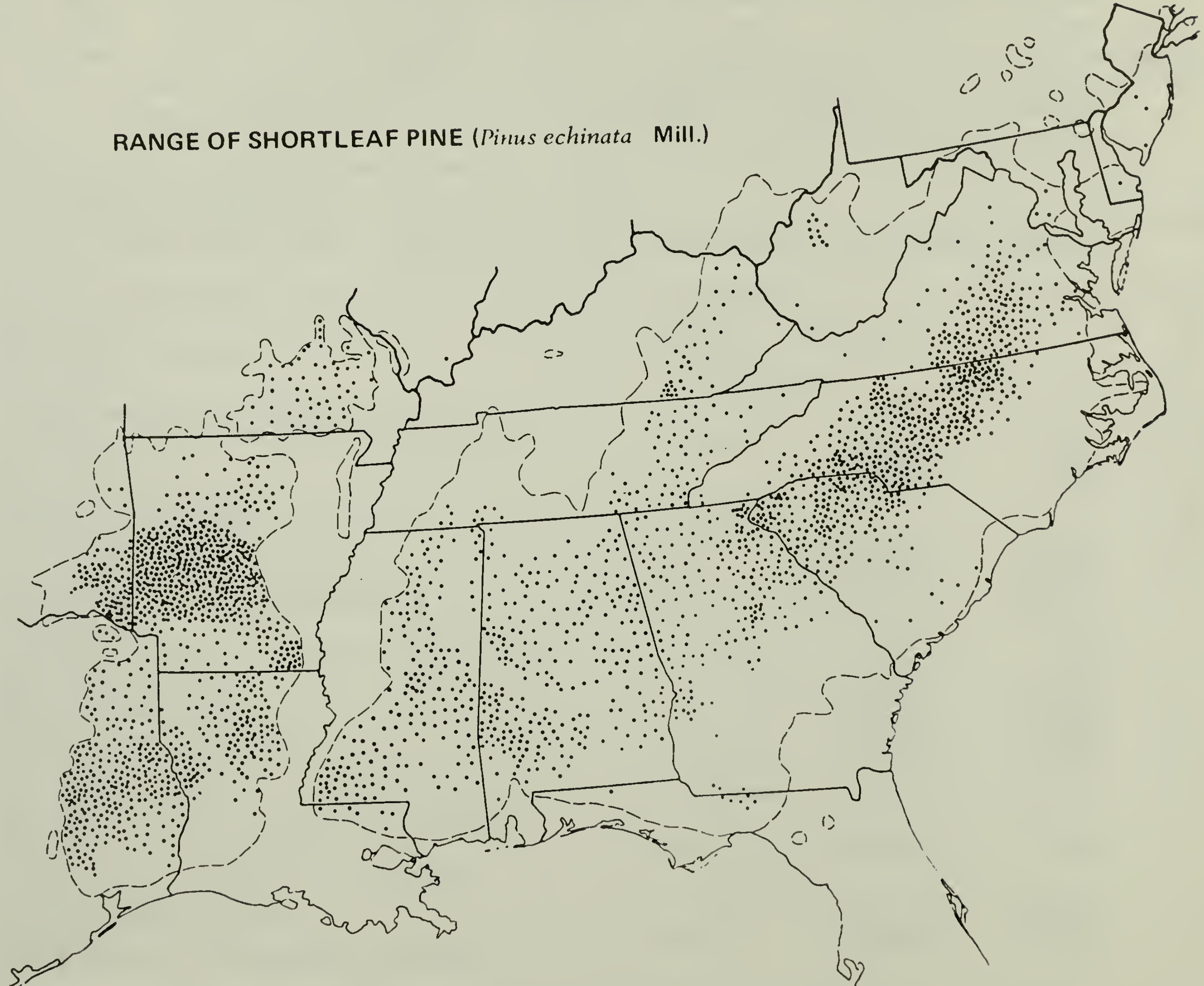
Date	Area	Volume Killed		$ Value	Source*
		Cords	Bd. Ft.		
1882-85	Texas				2
1890-92	Central Atlantic States				2, 10
1902-05	North Carolina, Georgia				2
1906-08	Eastern & Western Virginia				10
1911-24	Southwide				4, 6, 7, 8, 10
1926	Texas				2
1929	North Carolina, Virginia				2
1931-32	Southwide				2, 7
1937	Virginia				2
1938	Virginia, East Tennessee				2, 8
1939	Virginia, East Tennessee, Texas				2, 8
1945-48	East Tennessee		758,000	9,279	8
1947	Florida				3
1949	North Carolina, East Tennessee				8
1950	North Carolina, East Texas	4,000	3,200,000		2
1951	North Carolina		300,000	4,500	1
	East Texas	50,000	55,000,000	925,000	1
1952	Mississippi		30,000,000	450,000	1, 5
	South Carolina		10,000	150	1
	Virginia		25,000	375	1
	North Carolina	Minor			1
	Kentucky		30,000	450	1
	Mountains-Tennessee	Minor			7
	Florida	Minor			1, 3
	Georgia		300,000	4,500	1
1953	Alabama	Minor			1
	Texas	Minor			1
	Western North Carolina		12,200,000	180,000	1
	Mountains-Tennessee		1,300,000	20,000	1
	Georgia		300,000	4,500	1

Table 2 - Continued

Date	Area	Volume Killed Cords	Volume Killed Bd. Ft.	$ Value	Source*
1954	North Carolina, Mountains-Tennessee, Virginia	60,600	30,000,000	450,000	1, 8
	Alabama, Mississippi	Minor			1
1955	Piedmont N.C. and S.C., N. Georgia and Central Virginia	42,100	15,500,000	513,800	1, 7
	Kentucky, Alabama, Mountains-Tennessee, and Mississippi	Minor			1, 8
1956	Mountains & Piedmont of North Carolina		1,700,000	42,500	1
	Northern South Carolina		600,000	15,000	1, 7
	Northern Georgia		150,000	3,750	1
	Mountains-Tennessee		3,300,000	82,500	1
	Mountains-Virginia, Mississippi, Alabama and Texas	Minor			
1957	Western N.C., East Tennessee, N.E. Georgia, N.W. South Carolina		6,000,000	150,000	1, 7
	S.W. Mississippi		1,204,000	30,100	1
	Alabama, Louisiana	Minor			4
1958	East North Carolina		150,000	4,500	1
	S.E. Texas		10,000	300	1, 9
	N. Central Alabama, Mountains-Tennessee	Minor			1, 8
1959	South Carolina		80,000	2,400	1
	East Texas	144 Spots			1
	Mountains-Tennessee	Minor			8
1960	East Texas	30,000	10,000,000		1
	Mountains-Tennessee	Minor			8

* 1. USDA, Forest Service, 1951-1960. Southeastern Forest Experiment Station Annual Reports.
2. Thatcher, Robert C., 1960. Bark Beetles Affecting Southern Pines: A Review of Current Knowledge. Southern Forest Experiment Station Occasional Paper 180.
3. Chellman, Charles. Personal correspondence. Southern pine beetle in Florida State Records.
4. Nachod, L. H. Personal correspondence. Southern pine beetle in Louisiana State Records.
5. Cook, Joe. Personal correspondence. Southern pine beetle in Mississippi State Records.
6. Doggett, C. A. Personal correspondence. Southern pine beetle in North Carolina State Records.
7. Remion, Michael. Personal correspondence. Southern pine beetle in South Carolina State Records.
8. Kauffman, Bruce. Personal correspondence. Southern pine beetle in Tennessee State Records.
9. Billings, Ronald. Personal correspondence. Southern pine beetle in Texas State Records.
10. Morris, Caleb. Personal correspondence. Southern pine beetle in Virginia State Records.

RANGE OF SHORTLEAF PINE (*Pinus echinata* Mill.)



Reprinted from A FOREST ATLAS OF THE SOUTH, USDA, Forest Service.

CONTRIBUTORS

STATE PEST CONTROL SPECIALISTS

Alabama	Jim Hyland
Arkansas	Jim Northum
Florida	Wayne Dixon
Georgia	Terry Price
Kentucky	Kentucky Division of Forestry
Louisiana	Ken Jeane, Rich Goyer
Mississippi	William Lambert
North Carolina	Coleman Doggett
South Carolina	Mike Remion, Andy Boone
Tennessee	Bruce Kauffman
Texas	Joe Pase
Virginia	James Capony, Tim Tigner

FEDERAL PEST CONTROL SPECIALISTS

USDA, Forest Service, State and Private Forestry	Pat Barry, Wes Nettleton, Russ McKinney, Ken Swain, Forrest Oliveria

DATE DUE

GEORGIA FORESTRY COMMISSION

John W. Mixon
Director

$4760/2250